THE

FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL

VOL. 58 Thursday, March 10, 1938 No. 1125

PUBLISHED WEEKLY

Subscription Terms : 17s. 6d. per annum.
Foreign and Colonial : 20s. per annum.
All Subscriptions are payable in advance.

All Communications to be addressed to the Editor, the Advertisement Manager, or the Publisher of

THE FOUNDRY TRADE JOURNAL
49, WELLINGTON STREET, LONDON, W.C.2

Telegraphic Address : "Zacatecas, Rand, London."
Telephone : Temple Bar 3951 (5 lines).

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF

The Institute of British Foundrymen

The Institute of Vitreous Enamellers

The Welsh Engineers' and Founders' Association

and

The Foundry Trades' Equipment and Supplies Association

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British Standard Specifications for Grey Iron

The British Standards Institution have just published* a revised edition of their specification for General Grey Iron Castings and a new specification for High-Duty Iron Castings. The revisions in the former are mainly of detail, the specified strengths remaining unaltered. The main features of the revision are the reduction of the sections represented by the various bars and the introduction of two new bars, one 0.6 in. dia. to cater for the lightest castings and the other 1.6 in. dia. intermediate between the original "M" and "L" bars.

The High-Duty Cast Iron Specification has been produced to cover the very large number of castings now being manufactured with tensile strengths over 12 tons sq. in., which is the high limit in the general specification. In these columns (February 21, 1935) it was suggested that three grades—16 to 20; 20 to 24; 24 to 33—might be specified as representing present practice, but the specification is more modest in its demands, and the minimum tensile requirements for each grade are as follow, the range being the variation allowed for the different size bars: Grade 1, 12.5 to 15.0 tons sq. in.; grade 2, 15.0 to 18.0 tons sq. in.; grade 3, 18.0 to 22.0 tons sq. in.

A large majority of castings produced by iron-founders who are working along scientific lines will fulfil the requirements of grade 1, and this grade might quite reasonably have been added to the general specification. Grade 2 is intended to cover the higher class of iron produced by ordinary methods, with or without the use of alloy additions, whilst the third and highest grade will generally require the use of one of the many special processes now available for producing special cast iron, such as inoculation or superheating.

The American specification for cast iron makes no distinction between "general" and "high duty," but has seven grades ranging from 9 to 27 tons per sq. in. tensile. We welcome the separation of the two classes of iron in the British Specification as an indication to buyers that for general work the higher grades are unnecessary. This point is brought out in the foreword to the high-duty iron specification, which includes a reference to the additional cost of high-duty cast iron and the necessity for using discretion in the selection of grades.

We also welcome the appearance of this high-duty cast iron specification, as we believe that it will be a stimulus to both the demand for, and the supply of, improved cast iron, and generally to widen the scope of cast ferrous products.

* B.S.S. 321/38, General Grey Iron Castings; B.S.S. 786/38, High-Duty Iron Castings. Price 2s. 2d. each, post free, from B.S.I., 28, Victoria Street, London, S.W.1.

Assessing the Business Position

We are now in a better position to estimate the business position in relation to the recession about which so much has been said. Indeed, if the country could have been talked into a slump, it would undoubtedly have been so. That there has been and is a recession cannot be denied, but there is ample evidence that it is temporary. The chairmen of the leading banks have all been united in their view that there is, and need be, no slump. The reports from the British Industries Fair have been excellent. The huge defence programme, progress on which has been announced, will not reach the peak immediately in view until 1939. The steel industry had a record high year in 1937, with an output of very nearly thirteen million tons, well in excess of the estimated total. Deliveries are easier, and industry will benefit from the removal of the hectic conditions of a few months ago. Making due allowances for short months and holiday periods, pig-iron production showed an almost continuous rise during 1937. The state of the stock markets probably accounts for a good deal of slump talk, but there is little doubt that American conditions influence stock prices more than they affect our industrial productivity, and it is good for industry that speculators should be unable to force up commodity prices to unduly high levels. There was during 1937 a good deal of overbuying of raw materials by industries fearing a scarcity and scarcity prices after a long period of hand-to-mouth buying and depleted stocks. The lull is largely due to the partial exhaustion of these stocks and price stabilisation has done a good deal to make forward buying unnecessary. The seasonal revival of building and the housing programme should keep establishments catering for the trades involved at good pressure. Although retail trading returns are good, the recession has been confined to industries serving home and not export markets, and the Secretary for the Department of Overseas Trade has told us that the situation does not contain the elements that usually precede a slump. Indeed, he hinted that if the U.S.A. could settle its internal difficulties there might be danger of a boom, from which many business men would pray to be delivered.

Outlook for Base Metals

By "ONLOOKER."

Any student of the base-metal markets looking back for twelve months could not but be struck by the striking change which has come over the situation in that comparatively short space of time. A year ago we were looking forward to a period of increasing consumption due to the Government's programme of armaments expansion, while in the United States the current of trade was rising, and there was every expectation that 1937 would be a good year. Unfortunately—except for those who were clever enough to make money out of the rise—the markets got entirely out of hand and finally boiled over after climbing up to absurdly high levels.

This ramp in base metals did a lot of harm, for consumers and merchants were persuaded to buy far in excess of their requirements, and since many of them neglected to hedge against this holding, losses were heavy. The aftermath of this trouble is still being felt, and is undoubtedly operating to put a check on business. The main adverse feature of the present situation is, however, the position in the United States, where confidence is sadly lacking, and the constant strife between big business and the President keeps everyone on tenterhooks and militates against enterprise in trading.

One Extreme after Another

That extremes are dangerous has been proved up to the hilt during the past twelve months, and the worst of it is that one extreme leads to another, so that after a spell of unduly inflated prices one may expect a period of depressed values when quotations will rule too low. It has already been said that there was serious overbuying in the early part of last year, as a result of which purchasers accumulated too much stock and then stayed out of the market for a period of some months. It is now some time since they began to buy again, but not by any means in the style of the spring of 1937, for they have adopted a hand-to-mouth policy which keeps producers guessing and will probably in the long run lead to prices being driven down too far for safety. As a matter of fact, that time has probably already arrived, but that is not to say that we are on the eve of an upward movement. Copper, for example, has come back to the lowest point reached by electro last year, while to match the present price of spelter one has to go back to September, 1936. Both lead and tin are depressed, and give every indication that they will fall to lower levels before an upward turn comes. One way and another, the base metals are not in good fettle at the moment, and sentiment is bearish about the future, especially with reference to America, the world's largest user of tin.

No Money Scarcity

When all has been said, however, about the adverse factors in the situation, the fact remains that metals have fallen to a very low level, and must be regarded as being in a buying zone. No speculator would expect to make a fortune by selling short at the present time, and it is probably safe to say that the bulk of the selling just now is hedging by producers either for settlement by buying back when sales to consumers come along or for liquidation by putting metal on warrant. This is certainly being done in the case of spelter of Continental origin, and there is also a fair amount of rough copper coming to London against sales of standard. It must not be forgotten that there is always money seeking investment, and the present bank rate level indicates that money is far from scarce. The base metals occupy a most important position among the commodities, and have always been attractive from an investment point of view. They are certainly getting down to an attractive level now.

Centrifugal Casting of Grooved Rollers

In "Liteince Delo," an article by M. M. LEVIN and S. E. ROSENFELD describes tests made on an experimental apparatus to ascertain the possibility of producing the longitudinally grooved (toothed) cast iron rollers of flax breakers by the centrifugal process. For the purpose of the experiments, the rollers were cast in cores, lined moulds, sand moulds and cast-iron moulds. Various forms of pouring spout were also used with the object of discovering the optimum shape. The influence of the speed of rotation of the mould was also investigated, and the article concludes with a description of the various defects and the methods to be adopted for their elimination.

It is pointed out that the casting of such rollers by the centrifugal process would appear to be profitable if the moulds are made of sand, faced with a graphitic sulphite mixture. The moulds should be dried for 20 or 30 minutes in hot air. The optimum speed of rotation for casting is 480 to 520 r.p.m., and casting should be effected during a period of 5 or 7 seconds with metal at a temperature of 1,280 to 1,300 deg. C. As compared with casting in stationary moulds, the centrifugal process has the usual advantages, such as absence of cores, no metal expended in gates, short drying period for moulds and less floor space required. A particular advantage for the case under consideration is that rollers of greater length may be cast, thus increasing the output of the flax breakers.

Publication Received

Handbook of Information. Published by the British Standards Institution, 28, Victoria Street, London, S.W.1. Price 1s.

Most works executives have now come to regard this annual publication much in the same way that the outside representative looks upon Bradshaw. Its general appearance does not change materially, and with very little experience one can find just what one requires. Obviously, the first thing we sought was news of the publication of the new specification for high-duty iron castings, and quickly learnt that it had been passed for publication. For a specification of major importance, the passage of "this bill through all stages" has been, in comparison with most, remarkably rapid, and the intelligent and energetic co-operation of the appropriate committee of the Institute of British Foundrymen, presided over by Mr. P. Russell, has in a large measure been responsible for this.

Catalogue Received

Alloys of Bismuth. "Cerrobase," "Cerrobend" and "Cerromatrix" are the names which have been given to a series of alloys made by Mining & Chemical Products, Limited, of Shell Mex House, Victoria Embankment, London, W.C.2. Unlike many proprietary alloys, the composition of each is disclosed in its appropriate piece of trade literature. In very general terms, "Cerrobend" is for filling tubes to enable them satisfactorily to be bent; "Cerromatrix" for the building up of jigs and tools, and "Cerrobase" is for the manufacture of master patterns. Because it contains bismuth and tin, the latter is expensive, but as it can so very easily be remelted, it is not a consumable commodity and can almost be regarded as a capital investment. As it does not contract, but maybe very slightly expands, it does commend itself, especially as it has excellent casting properties, for the manufacture of master patterns.

Random Shots

An observant foreman has noticed that when East Coast hematite is used in his foundry the castings camber towards the east, and likewise when West Coast hematite is used they camber in that direction. Is this phenomenon worthy of the attention of Mr. E. Longden, who is an accepted authority on the subject of camber? A suggested remedy is that the Northampton area should produce a hematite, so that castings might be freed from this east and west bias. Alternatively, with a 50-50 mixture of east and west they ought not to camber at all.

* * *

"New Fields for Industry" say the Commissioners for Special Areas. If they are not careful there soon won't be any fields left in which to roam on a Sunday evening with the Sara of one's choice.

* * *

Mr. Edward Ott has been appointed assistant secretary of the Sheffield Chamber of Commerce. And has, of course, been received with a suitably warm welcome?

* * *

The pneumatic tyre was, curiously enough, invented by a veterinary surgeon. Had he been thinking of a plan to deaden the noise of his 'orse as it 'ammered on the 'igh road with its 'ard 'ard 'oof?

* * *

"When an enameller examines a bath for defects he first pays attention to the surface immediately over the foot-lugs," states Mr. J. T. Gray. On the other hand, when the missis examines little Tommy for defects after his bath she first pays attention to the surface immediately behind the lugs and immediately under the feet.

* * *

Rumour has it that amongst the inventions entered in the competition in connection with the Foire de Paris this summer, there will be a motor tyre that is guaranteed not to need replacing just when the income tax is due; a wireless set that consistently fails to transmit the words "War," "League of Nations," and the names of film stars, and also a toy that will keep the kids engrossed all Sunday, especially just after luncheon.

* * *

"As things are to-day many trains coming into London throughout the year carry some chemical official in its first-class compartment, coming for some almost unnecessary committee meeting or consultation," says the Financial Editor of one of the Brighter Dailies. Real efforts must be made to keep his sleuth hounds from prying into the activities of the B.I.A., the I.B.F. and the B.S.I. These initials are used expressly to mask the identities of the organi sations indicated.

* * *

Overhead in the "Queen's" last Quarter Day. "He is the sort of man who dribbles well up the field and then invariably shoots wide." "Not upon your life," said the other man, "he always fouls the goal-keeper."

* * *

"Visit Canada. Leave your worries and take your wife with you," says a tourist agency. Can't be done!

"MARKSMAN."

A Wall Calendar

We acknowledge with sincere thanks the receipt of a monthly tear-off wall calendar from the Standard Brass, Iron & Steel Foundries, Limited, Benoni, South Africa.

A Chemist's View of Metallurgy

By Dr. C. H. DESCH, F.R.S.

(Extracts from the Presidential Address delivered to the Institute of Metals.)

Related Activities

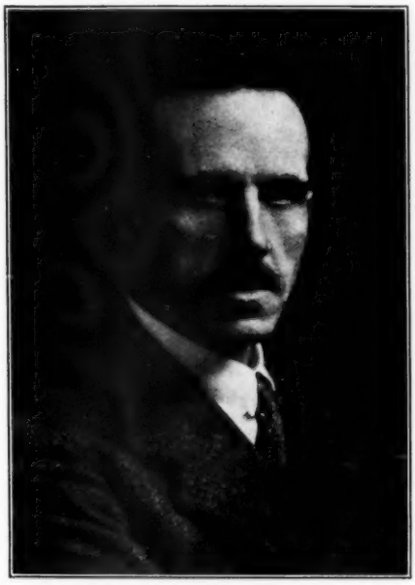
The scope of the Iron and Steel Institute and the Institute of Metals differs in one important respect. The field of the former embraces the mining and smelting of the ore and the coking of the coal used in the process, as well as the conversion of iron into steel and ultimately into finished products. Our own Institute deals only with these later stages, the mining and smelting of non-ferrous ores being the province of yet a third body of long standing: the Institution of Mining and Metallurgy. The work of this last lies largely abroad, especially among other units of the British Commonwealth of Nations, and its members are able to compare experiences gained in many remote regions of the world. It therefore needs three distinct Institutes to cover the whole field of metallurgy, and I cannot leave this point without calling attention to the fact that Sir Harold Carpenter enjoys the unique distinction of having successively occupied the presidential chair of all three.

This does not complete the tale, for there remain several important bodies concerned with special branches of metallurgy, notably the Institute of British Foundrymen and the Electroplaters' and Depositors' Society, the latter, by its affiliation to the Faraday Society, indicating its special relation to the study of physical chemistry. The British Non-Ferrous Metals Research Association and the British Cast Iron Research Association, again, although organised on a different basis, are also closely associated with the progress of metallurgical science. Each of these bodies has its distinct function, and, as a considerable degree of interlinking occurs through common membership, they are able to co-operate in many ways, with mutual advantage.

The Link of Metallography

In the course of 23 years of teaching both ferrous and non-ferrous metallurgy, and of later experience in a great research laboratory, I have had occasion to survey the subject of metallurgy as a whole, and I have mentioned these facts of organisation in order to show the practical difficulties in the way of so treating it on a large scale. The separation between the ferrous and non-ferrous industries and between the industry of smelting and refining on the one hand, and of alloying, casting, working and finishing on the other, presents a real obstacle to unification, except on the educational side. There is, however, one department of metallurgy in which no such difficulty need arise. That is the study best known as metallography, which is concerned with the structure and properties of metals and alloys, making use of methods based on physics and on chemistry. The metallographer, whether dealing with ferrous or non-ferrous metals, finds himself faced by similar problems, and is forced to consider them in the same way.

The structure of ingots has received most attention from research workers on steel, on account of the large scale of operations in steel making and of the known profound effects of heterogeneity on properties, but as research proceeds it is found that the problems of the mechanism of freezing are common to both branches of metallurgy. The distinction between columnar and equiaxed crystallisation, the effects of differential freezing, and the factors which produce inverse segregation, interest the maker of ingots of brass or of light alloys as well as the steel maker, and investigations carried out for the one throw light on the problems of the other. The hardening of steel by quenching has seemed to the practical man, and for long also to the scientific worker, to be a process unique of its kind, since the increase in hardness so produced is far greater than in any other system, whilst softening as the result of quenching is actually the more usual effect. On the other hand, age-hardening, first observed in the light alloys of aluminium and now found to be producible in an extraordinary variety of alloys, proves to involve internal changes in the crystalline edifice which are closely analogous with those in the hardening of steel. Whether we are investigating changes of this kind or those which are brought about in metals and alloys by deformation and by annealing, we find that there is no essential difference between the alloys of iron and those of other metals, and that facts observed in the study of one group may be used to illuminate the behaviour of the other, so that the distinction between ferrous and non-ferrous metallurgy in this field becomes purely artificial.



DR. C. H. DESCH
(President of the Institute of Metals).

This fact brings with it certain administrative difficulties. An investigator who is making a complete study of a binary system of alloys containing iron can send his Papers to this Institute so long as the percentage of iron (whether atomic or by weight I am not sure) is less than 50, but after that point has been passed he should publish through the Iron and Steel Institute. Such minor difficulties can no doubt be adjusted; I only mention them as illustrating the essential unity of the scientific study of metals, a unity which, I feel assured, will be more widely felt with the advance of our organisation. Such divergence as exists has to be borne in mind in devising any scheme for increased co-operation in publishing and in the abstracting of metallurgical literature. This task is a formidable one. The mass of such literature has grown rapidly in recent years, being notably swollen by the great output of Soviet Russia, and the problem of co-ordinating abstracts is receiving serious attention on both sides of the Atlantic. It is a problem which we shall have to face in the coming years.

Origin of Chemistry

Metallurgical science is based on physics and chemistry. Historically, its connection with chemistry is much the older, since in fact chemistry arose out of the empirical knowledge acquired by the craftsman in the preparation and handling of materials, notably of metals. The view that we were once taught, that chemistry developed out of alchemy, can no longer be maintained. Although it lasted many centuries, alchemy was an aberration, and not a stage in the linear historical filiation of science. The modern transmutation of elements, one of the triumphs of the science of to-day, owes nothing to alchemy either on the side of theory or on that of practice. During all the lifetime of that aberration, however, facts concerning chemical substances, including metals, were being accumulated, and by the time of Agricola's great work, published in 1556, a great body of metallurgical knowledge, purged of alchemical and astrological superstition, was ready for the scientific chemists of the two following centuries. The study of the oxidation of metals played a great part in the growth of modern ideas of chemical combination, from the time of Boyle to that of Lavoisier, and Davy, Faraday and their contemporaries constantly used the reactions of metals as a means of advancing their science.

Within the last few years, we have seen a great transformation of metallographic research by the introduction of new physical methods of study. Chief among these is the determination of crystal structure by means of X-rays. The original discovery of Laue, so brilliantly applied and extended by Sir William Bragg and his son, has proved of incalculable value in metallurgical research, giving us a new insight into the internal structure of solids, assisting us greatly in the study of changes during cold-working, recrystallisation, age-hardening, and other processes, and furnishing a rapid and accurate method of determining phase equilibria in systems of alloys. The physicists, having been brought into contact with metals in this way, have found that metallic structures lend themselves well to theoretical treatment, and we are indebted to Professors Bragg, Mott, Borelius and others for an explanation of changes in certain alloys, such as those of gold and copper, which had puzzled metallurgists, and now reveal themselves as changes from a disordered to an ordered arrangement within a lattice which otherwise retains its character. These discoveries have a wide-reaching importance, and seem certain to throw light on other processes in alloys which affect profoundly their technical properties.

It is clear that metallographic research tends more and more to become an application of physics to the special case of metals. It must not be thought, however, that this constitutes the only approach. For the research worker of the future, metallurgy should be essentially a post-graduate subject, to be studied after a thorough training in physics or in chemistry. (I regard this as distinct from the more technical courses in metallurgy which are usually given, which aim at training men for the control of works operations.) It may well be that we shall draw more largely in the future for our metallurgical research workers on those students who have distinguished themselves in physics, but not exclusively on them.

Atomic Theories

It is characteristic of chemistry that its astonishing growth during the nineteenth century has been made with the use of a bare minimum of hypothesis. Atomic theories are very old. From the Greeks onwards, thinkers from time to time have found an intellectual satisfaction in picturing the world around them as being made up of atoms, and of explaining natural phenomena in terms of those atoms, but knowledge was not advanced thereby, nor was it possible to base scientific predictions on such speculations. Successful prediction is the true test of the value of an hypothesis, and these conceptions remained barren. When, 134 years ago, John Dalton took up this ancient hypothesis and used it in chemistry, he gave it a form which bore no real relation to the doctrines of Democritus and Lucretius. He said that the quantitative laws of

combination of elements were such as would hold if each element were made up of similar atoms, and certain ratios existed between their weights. On that simple foundation the whole of chemistry has been built up. And observe, it was not necessary that the atoms should have a real existence. Some chemists thought it unnecessary to assume them except as a convenient working hypothesis, but by using it as such they were able to build up a great body of chemical knowledge. It soon became evident, from a study of chemical reactions, that some atoms in a molecule were more closely connected with one another than with other atoms, and the notion of structure was introduced. Even after, by the discovery by Berzelius in 1832 of isomerism (the existence of compounds with different properties, although containing the same number and the same kind of atoms), it had become necessary to arrange the atoms composing a compound into a pattern which could be varied, Crum Brown could write, in 1867:

"While there can be no doubt that physical research points to a molecular constitution of matter, it is perfectly indifferent to a chemist whether his symbols represent atoms or units; and graphical formulæ would be as useful as they are now, were it conclusively proved that matter is continuous."

Microscopical Examination

The oldest metallographic method, that of microscopical examination, is essentially chemical. Although we have occasionally to examine unetched specimens under the microscope, as in the identification of non-metallic inclusions in a polished surface or in the study of surface changes in a deformed specimen, we make far greater use of etched specimens. In an alloy composed of more than one phase, the differing resistance to attack by reagents produces contrast between the phases, but even where only a single phase is present, a pattern is formed, which may arise in more than one way. A variation of composition within the individual grain results in "coreing," which is found when the rate of crystallisation of a solid solution has been greater than that of diffusion in the crystal, so that the phase is not in a state of equilibrium, although it may be made homogeneous by annealing. This coreing may produce a false impression. A low magnification often appears to show a sharp boundary between the core—the skeleton or dendrite which was first formed—and the peripheral material, thus suggesting that two phases are present. Under a higher magnification the boundary usually lacks sharpness, and on continued etching with the same reagent it moves inwards. The false impression is thus due to an electrolytic effect, connected with Tammann's "resistance limits," and it may even be used as a means of investigating solid solutions more minutely.

The etched pattern of a truly homogeneous crystalline phase, whether a pure metal or a solid solution, originates in a different way. The reagent acts more rapidly along certain directions in the crystal than along others, so that the degree of attack varies with the inclination of its axes to the prepared surface. Neighbouring grains are thus unequally etched. Moreover, a higher magnification shows that the etching within a grain takes the form of minute geometrical pits, the "etch-figures." For a given crystal, under identical conditions of temperature, concentration of reagent, and time of etching, these pits approximate to a standard size. Larger pits, such as are formed on longer etching, may often be seen to be formed by the coalescence of smaller ones, so that their dimensions are a simple multiple of the unit. In this way, a unit has been recognised in iron and steel of 0.25 μ, in bismuth of 1.4 μ, in tin of 3 μ, etc. This fact has been used to support the hypothesis of a mosaic structure in crystals. It is not confined to metals, in fact examination of the form of etch-figures has long been used by crystallographers as one of the means of studying the symmetry of minerals. The mosaic theory of crystals was devised to account for their physical and mechanical properties, but the chemical evidence points in the same direction, and, although little quantitative work has been done, the units derived from different observations indicate secondary structures of the same order of magnitude, allowing for the fact that multiples of the smallest unit may sometimes be predominant. Here, then, is a chemical method of investigating the internal structure of crystals of metals and of solid solutions. A crystal such as bismuth, which has both metallic and non-metallic properties, will be differently attacked by reagents according to their chemical character, and zinc, which may be etched either by an acid or by an alkali, gives different etch-figures under the two conditions. The form of the figures depends on the relative density of packing of the atoms in the more important lattice planes.

Polish by Etching

We have become accustomed to this roughening of metallic crystals on etching, through the formation of etching pits, as the inevitable result of chemical attack. It was therefore the more surprising to find that by the choice of a suitable electrolyte, the surfaces of metals may be electrolytically dissolved in such a way as to leave a perfectly smooth surface, sometimes having a reflectivity greater than that of a mechanically-polished surface of the same metal. This process, which is much more difficult to explain than the normal etching along lattice planes, is finding important practical applications, and calls for careful scientific study.

When a supersaturated solid solution has begun to lose its homogeneous character, as in the early stages of age-hardening, before any new phase has formed particles of appreciable size, chemical attack is sometimes a most sensitive detector of the beginnings of change. A striking example is that of an aluminium alloy containing 5 per cent. of copper, rendered homogeneous by quenching from 540 deg. C. By using a suitable etching reagent, a kind of faint Widmanstätten pattern soon appears on ageing, parallel with the increase in hardness, even at atmospheric temperature. At higher temperatures it appears in a shorter time, but even when the temperature is as high as 200 deg. C. this difference in etching properties is apparent long before there is any change in the lattice parameter, and still longer before any new phase can be detected by X-rays. This behaviour was first noticed in the alloys of copper containing about 2.5 per cent. of beryllium, which have to be aged at a relatively high temperature. A change in the appearance on etching, producing a hazy Widmanstätten pattern, accompanies the increase in hardness, and is earlier than the change in lattice parameter. Similar effects are found in the alloys of copper and silver, and in those of aluminium and magnesium.

It is not difficult to see why this should be so. If, as has several times been suggested, an early stage in age-hardening is the formation of two-dimensional sheets of foreign atoms, parallel with some set of closely-packed planes in the parent lattice, the resistance to chemical attack on such planes as have been changed must be altered, probably diminished, by the setting up of minute local electrolytic couples. The scale is far too small to represent distinct particles, hence the hazy pattern, but the directional effect is very obvious. There is, in the early stages of the process, nothing that can be called a second phase, but we are in a region of minuteness to which the phase rule does not apply.

Etching Potentialities

The subject of etching has scarcely received all the attention that it deserves. We choose etching reagents mainly for the contrast which they give, so that we may obtain the best photographs, and only rarely for their specific reactions. There are a few exceptions. The phases in the ternary and more complex alloys of aluminium are very difficult to distinguish by their appearance, and much empirical information has been collected on the selective effects of different reagents. Rather less has been done on the identification of the carbides in alloy steels, and here more experiments are certainly needed. The survey of ternary systems by means of X-rays, as developed by Dr. A. J. Bradley, does indeed tell us the composition of the phases present in a given alloy when in equilibrium, but we have often to examine alloys which are not in equilibrium, either in the course of industrial processes or when studying the rate of change in a solid transformation, and for such purposes more refined chemical methods would be most useful.

By varying the concentration of etching reagents or the time during which they act, their effects may be greatly altered, and in some etching processes, especially if electrolytic, an actual reversal may occur. Such effects probably depend on local polarisation, but we have no quantitative knowledge of them.

Chemical Analysis

It is not necessary to say much as to the importance of chemical analysis for metallurgical research. As a means of control of industrial processes it is the oldest and still the most generally applied. Analytical laboratories were introduced into metallurgical works before any use was made of the microscope or of physical measurements. (Mechanical testing is, of course, still older.) Even now, establishments which have no other scientific control may employ a works chemist, even though he be confined to the simplest of routine analyses, but analytical methods in the more highly developed industries are undergoing a profound change. With the increased use of highly-purified metals—aluminium, copper, zinc, lead, and cadmium are all obtainable in commerce with a purity of 99.99 per cent. or better—interest is being taken in the estimation of very minute amounts of foreign elements.

Oxygen Determination

That interest is by no means purely academic. The removal of a few hundredths or even thousandths per cent. of impurity may have a profound effect on the properties of certain metals, aluminium, for instance, becoming self-annealing like lead at a certain stage, and there is little doubt that before long we shall see a greatly increased practical use made of the special properties, both chemical and mechanical, of metals in the highest attainable state of purity. This is one of the reasons for the growing popularity of spectrographic methods, made quantitative by such devices as the logarithmic sector and the photometer. Some of the non-metallic elements do not lend themselves even to these improved methods, and special means have to be devised for their estimation. I would instance the determination of oxygen, hydrogen, and nitrogen in iron and steel. The total oxygen can now be determined with great accuracy by fusion in a graphite crucible and analysis of the evolved gases. The principle is simple, but it has taken much research, and the co-operation of many laboratories, to arrive at a satisfactory form of apparatus. The high-frequency vacuum furnace devised at the National Physical Laboratory embodies a number of improvements on earlier forms, and is now being adopted elsewhere. This method of estimating oxygen, and incidentally hydrogen and nitrogen, has now reached the stage at which workers in different laboratories obtain results as concordant as those expected in analytical work generally. Since skill in vacuum technique is essential, it can scarcely become a routine method until more trained workers are available, but the analyses now being made, in which institutions at home and abroad are co-operating, are proving most valuable in the study of the effects of manufacturing processes on the properties of steel.

The estimation of total oxygen is chiefly of interest to the ferrous metallurgist, but the second problem, that of determining how the oxygen in a metal is distributed, in inclusions of oxides or otherwise, has a wider application. Since it is essential to isolate non-metallic inclusions without altering their composition, solvents have to be found which will dissolve the metal and nothing else, without causing secondary reactions. This problem has been solved for the simpler steels, but certain elements interfere, and the conditions for obtaining correct results are also being sought through co-operative research, at the National Physical Laboratory and elsewhere.

Microchemical Methods

Microchemical methods, for some time used only in biochemistry, are becoming more popular, and much ingenuity is being expended in perfecting them for more general use. It is often an advantage to be able to make a complete analysis on a few milligrams of material, as in a study of the local changes during corrosion or abrasion. In the course of an investigation of ancient copper and bronze it has been found possible, by relating the impurities in metal objects from ancient sites to the composition of ores from different geographical regions, to supplement the well-known methods of comparing the shapes of objects and the types of pottery, and so to assist in tracing out the migrations of early peoples. A difficulty in the way of such work has been the natural reluctance of museum curators to allow drillings for analysis to be taken from a valuable object. Now that a complete analysis of a bronze can be made on 10 mg. of metal, the sample can be taken without any noticeable disfigurement. This is just one illustration of the usefulness of microchemical methods which, from their simplicity and cleanliness, are particularly attractive to a worker with skilful fingers. The micro-balance, an admirable product of the instrument-maker's art, has become a valuable auxiliary in the laboratory.

Conservation of Matter and Waste

The chemist, in the course of his studies, is inevitably impressed by the great principle of the conservation of matter. A substance can neither be created nor destroyed, a conviction which modern physical theory has done little to disturb. It is true that on the cosmic scale the annihilation of matter is believed to be proceeding at a prodigious rate, while serving as a source of radiant energy, but we do not meet such processes in our terrestrial life. Again, the transmutation of elements has been found to be practicable, and the artificial production of radioactive elements seems likely to supplement in a most valuable way the natural supplies of radium, but such processes involve a great expenditure of energy in proportion to the yield, and there seems to be no likelihood of the production of, say, copper or tin in quantities by such a method. It follows, then, that we are confined to the deposits of those metals existing in the earth's crust for the future supplies of metals and alloys. Those deposits, forming an important part of the natural resources of the world, are not inexhaustible. For some of them, perhaps, the time when they will be exhausted can be calculated only too easily. There is an obvious and understandable tendency to exploit the supplies of a particular metal to the utmost, without reference to the needs of future generations, but the chemist must necessarily look on such a policy with mistrust. All utilisation of metals involves waste; the processes of corrosion and abrasion continually diminish the stock available for use, so that production has not only to meet new demands but must make good the unavoidable losses. Is not some plan of conservation needed?

Distribution of Mineral Resources

Surveys of existing resources are not lacking. Geologists and prospectors, sometimes using the modern resources of geophysics, have explored the greater part of the earth's surface, and although extensive new discoveries are always possible, the advancing knowledge of the structure of the earth makes them increasingly unlikely. Estimates of the stocks remaining in the known worked or unworked deposits must be subject to very large errors, but we know that certain metals will be exhausted long before others. There is plenty for our own and a few more generations, but will posterity find itself lacking in what we regard as necessaries through our thriftlessness? It is a question which naturally presents itself to a chemist, and one which metallurgists may be asked one day to answer.

Moreover, the metallic ores are very unequally distributed over the world, and as many of them are essential to the economy of any nation having a mechanical culture, their availability is a matter of great international significance. Without entering into the field of politics, we must be aware that this problem—the distribution of natural resources—is one which the most thoughtful statesmen regard as of the utmost importance. The subject bristles with difficulties, but it is clear that efforts will have to be made to study it in all its bearings. I am not thinking of war conditions, although they bulk so largely in the public mind, but of the peaceful conduct of international commerce, which must continue and develop if the world is not to lapse into barbarism. The relative importance of the several metals varies from time to time with the progress of technology, and with the policy of States seeking to conserve their resources or to avoid the importation of metals from abroad. Note, for example, the vast increase in production of aluminium, and more recently also of magnesium, in Germany, replacing copper and its alloys and even steel in order to use so far as possible raw materials of native origin. A study of the regulations of the Four Years Plan and the explanatory articles, as published week by week in "Metallwirtschaft," is most instructive in showing to how great an extent one metal may be substituted for another, and alloys produced for new services, when sufficient technical skill and knowledge are applied to the problem.

To approach such questions as these, the first requisite is accurate knowledge. To arrive at a great invention by way of a happy guess is becoming less and less likely, and it is now generally recognised that industry must progress by means of increasing research, based on the accumulated knowledge of a great body of workers of the present, and still more of past, generations. To make such knowledge as available as possible, and to encourage, by the interchange of ideas, further additions to it, is the function of this Institute and of similar organisations. I conclude, then, by urging that an Institute devoted to metallurgical science and practice has a great public function to perform, and that its continued flourishing is an object which should appeal to all concerned with the great metallurgical industries, on which the prosperity of this country so largely depends.

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tiring President inducted into the chair the newly-elected President, Dr. C. H. Desch, F.R.S. (Director of the Metallurgy Department of the National Physical Laboratory, Teddington).

Dr. Desch then delivered his Presidential Address on "A Chemist's View of Metallurgy." Extracts are printed elsewhere in this issue.

Yesterday (Wednesday) morning and afternoon were devoted to the presentation and discussion of Papers, whilst in the evening the annual dinner and dance were held at Grosvenor House, Park Lane.

To-day (Thursday) members are paying visits to the G.E.C. lamp and glass works at North Wembley and the L.P.T.B. bus works at Chiswick.

The Institute of Metals

ANNUAL MEETING IN LONDON

The thirtieth annual general meeting of the Institute of Metals opened in London on Tuesday evening. The President, Mr. W. R. Barclay, O.B.E., was in the chair at the opening of the proceedings, his place being taken later by the new President, Dr. C. H. Desch, F.R.S.

The Report of Council for the year ended December 31, 1937, presented by the Secretary, stated that the year was one of exceptional activity and of considerable progress in many directions. The Institute's membership, now totalling 2,166, had again shown an increase over the previous year, and in the hope that the growth would continue the Council had felt encouraged to develop plans for the improvement of publications and to engage in discussions with the Iron and Steel Institute for closer collaboration and for increased joint responsibilities in several directions.

The raising of an Endowment Fund which promised to reach £20,000, had appreciably strengthened the financial position and had justified the Council in contemplating forward movements with much greater confidence than had hitherto been possible.

The Honorary Treasurer, Mr. John Fry, presented his report, which showed a surplus on the year's working of £49 and an increase in subscription income of £199. The balance sheet indicated that the Institute's assets had increased in value during the past year from £7,343 to £19,243—largely as a result of the establishment by the retiring President, Mr. W. R. Barclay, of the Endowment Fund referred to above.

Election of Officers

The Secretary announced the election of the following officers for the year 1938-39:—*President*, C. H. Desch, D.Sc., F.R.S.; *Vice-President*, Prof. J. H. Andrew, D.Sc.; *Members of Council*, Mr. J. W. Donaldson, D.Sc., Engineer Vice-Admiral Sir George Preece, K.C.B., and Mr. H. S. Tasker, B.A.

The election of 118 new members was reported.

Co-operation with the Iron and Steel Institute

The President announced that the Council of the Institute of Metals had accepted an invitation from the Council of the Iron and Steel Institute to share office and other accommodation at 4, Grosvenor Gardens, London, S.W.1. He said that this fine and conveniently situated building (formerly the American Embassy) had been leased by the Iron and Steel Institute, and adequate accommodation for the Institute of Metals had been provided as from June 24, 1938. Both Institutes would retain their identity and staffs, but there would be a joint library and reading room, whilst certain committee rooms would be in common.

Members of both Institutes, the President said, would gain by the resulting closer co-operation and pooling of library and other facilities. The scheme followed naturally upon that announced last year whereby members common to both Institutes paid a reduced subscription, and newcomers could join both Institutes on payment of £7 7s. instead of £10 10s.

Award of Institute of Metals Medal

The President then presented the Institute of Metals Medal to its first recipient, Sir William H. Bragg, O.M., F.R.S. The President said that the medal—in platinum—had been offered by the Mond Nickel Company, Limited, to the Council for "outstanding services to non-ferrous metallurgy, whether on the practical or scientific side, without restriction of nationality, or membership of the Institute."

After Sir William Bragg had acknowledged the presentation to him of the medal, the re-

(*Concluded in previous column.*)

Institute of British Foundrymen

EAST MIDLANDS BRANCH ANNUAL DINNER

The annual dinner of the East Midlands Branch of the Institute of British Foundrymen was held at the Assembly Rooms, Derby, on February 26. Mr. W. T. Evans (Branch-President) presided over a company of about 150. Among those present were Mrs. W. T. Evans; Mr. C. W. Bigg (President of the Institute) and Mrs. Bigg; the Mayor and Mayoress of Derby, Alderman E. E. Paulson and Mrs. Paulson; the Deputy Mayor of Derby, Councillor Mrs. Petty, J.P.; Mr. E. J. Fox (managing director, Stanton Ironworks Company, Limited) and Mrs. Fox; Prof. Wortley; Mr. W. H. Innes and Mrs. Innes; Mr. N. Cooke and Mrs. Cooke; Mr. S. H. Russell (Treasurer of the Institute) and Mrs. Russell; Mr. T. Makemson (Secretary of the Institute); Mr. R. H. Buckland (Junior Vice-President, East Midlands Branch); Mr. H. Bunting and Mrs Bunting; Mr. P. A. Russell and Mrs. Russell; Mr. A. E. Peace; Mr. T. Goodwin and Mrs. Goodwin; Mr. B. Gale (Hon. Secretary of the East Midlands Branch) and Mrs. Gale.

Level of Pig-Iron Prices Too High

After the loyal toast had been honoured, MR. E. J. FOX (managing director, Stanton Ironworks Company, Limited) proposed the toast of "The Institute of British Foundrymen and the East Midlands Branch." Speaking as a foundryman pure and simple, who remelted during a week, for foundry purposes, a tonnage of iron in excess of any foundry in the world, he remarked that, whilst cast iron was undoubtedly an economic and commercial product, he looked upon it only as such as long as it could be brought into useful work at a moderate price. As soon as the price rose to uneconomic levels, it was opening the door to alternative materials, and, unfortunately, the present price of foundry pig-iron was already having that effect. Lest they should think that the pig-iron producer was responsible for that state of affairs, he would tell them that the price of foundry pig-iron had been increased 52½ per cent. over the past two years; that the price of coke for the production of that pig-iron had been increased 120 to 130 per cent. over the same period, and that the price of coking slacks, from which the coke was made, had been increased 80 per cent. over the same period.

The villain of the piece, therefore, was fuel, and unless those prices were substantially reduced, he forecast that the slackening in demand, which he fancied they had all tasted of recent months, might result in a further curtailment of consumption. This was for two reasons: firstly, because nobody was going to buy at high prices unless he was bound to do so; secondly, because, as he had previously mentioned, as soon as prices rose, they all looked round for alternative materials and for alternative methods of achieving the same results.

As a manufacturer of pig-iron he realised that prices were too high; as a consumer of pig-iron he realised that for the health of his foundry products, the price of that pig-iron must somehow be brought down, but that could not be done unless coal prices were reduced.

Better Training Facilities

He was pleased to realise that one aspect of the foundry trade was now receiving the attention it had long deserved. He referred to efforts being made for the technical and scientific training of foundry workers. In October, 1934, a three- or four-year course was inaugurated at the University of Sheffield for students who had previously matriculated. It was too early at the moment to judge the results of this venture. Another scheme, sponsored by the British Cast Iron Research Association, would give a general insight into the technical and administrative side of foundry work. He understood that scheme commenced at the Birmingham Technical College during 1935. The course was to be of twelve months' duration and was open to foundry workers who had had at least twelve months' practical training. That venture was full of promise.

The British foundryman was somewhat slow in taking kindly to pig-iron cast in chill moulds. But having experience with one machine for taking charge of the pig-iron at their Holwell furnaces he could really see no objection to that practice. On the other hand, there were the two advantages that the pigs were uniform in size and free from adhering sand. Of course, the fracture did not agree with the fracture of iron of a similar analysis cast in a sand bed, but this was immaterial when buying to analysis, as in remelting the resulting metal was normalised according to the silicon content. As he forecast that foundry pig-iron in the future would be largely machine-cast, it followed that foundrymen would need to revise their judgment of fracture.

Mechanisation

Referring to mechanical control in the foundry, Mr. Fox believed that it was possible to over-mechanise, particularly in regard to machinery dealing with an abrasive material like sand. During the past ten years, he said, a great deal of experience had been gained on that subject, and to-day foundry machinery could be designed to withstand heavy wear and tear with a reasonable amount of depreciation. It was pleasing to note that, in spite of foundry mechanisation having been a feature of Continental practice prior to its adoption in this country, British engineers had overtaken their Continental rivals, and to-day one's requirements could be satisfied largely from our own engineering shops. The advantage to be gained by a mechanised foundry was twofold; in the first place, cost of production was much reduced, and, secondly, due to better control over the materials used, an improved product was obtained.

He had recently duplicated a mechanised continuous-casting plant at the Holwell Works, and this plant was producing green-sand castings at a high rate of production, which were comparable in quality and finish with the best high-grade castings made in dry-sand moulds.

He was pleased to realise that the Institute of British Foundrymen had established a liaison with the Cast Iron Research Association for the purpose of establishing a clearing house for the dissemination of technical knowledge and its application in practice.

MR. C. W. BIGG (President of the Institute), in responding to the toast, said they had been very glad to hear Mr. Fox refer to their efforts for education, and he would like to thank him for the remarks he had made about the Institute. Mr. Fox was in a position which enabled him to judge and assess the value of the work the Institute was doing, and the members could derive a great deal of satisfaction from the high esteem in which Mr. Fox undoubtedly held them. He showed that esteem in some practical ways, and Mr. Bigg assured Mr. Fox that his help and encouragement were very much appreciated.

He congratulated the East Midlands Branch in making their annual dinner a function to which they could invite the ladies. He was very glad to be in the position of President of the Institute attending the dinner of the Branch, and in responding to the toast, he was happy that his name was associated with that Branch.

Pre-eminent Position of Local Industries

MR. W. T. EVANS (Branch-President), also responding to the toast, said he particularly wanted to thank Mr. Fox, because without any doubt he was one of the greatest supporters of the Branch. They in the East Midlands Branch were fortunate in having in their area some of the largest and most progressive foundries in Britain, in fact it would be no exaggeration to state that some had a world reputation. Stanton was now, he believed, producing 6,000 tons of castings per week, of a better and more serviceable quality than ever they had been before; that output was perhaps a world record. Rolls Royce required no words of his to advertise their success, and they had developed their aluminium alloys to a high standard of excellence. Qualcast was a firm second to none as founders of reputation for grey-iron castings and alloy steels, and as a side line they had placed on the world market lawn mowers of good quality, at the right price, having to manufacture them at each side of the world to catch the grass crop. He mentioned one further firm, Ley's, who, he said, were the largest producers of malleable cast iron in Europe; their tonnage output had increased five times since he himself was last President of the Branch. Those foundries were members of, and gave active support to, the Institute. Mr. Jobson, one of their oldest members, and Mr. Fox had given financial aid in no small way, for which they were more than grateful. Ley's, he believed, had the largest number of members for any one firm.

Mr. Evans was also pleased to say that, thanks to Mr. Gale, the hon. secretary, the Branch members kept their subscriptions up to date. The Institute used all the money it could obtain for two objects, primarily the education of its members, and secondly for improving the status of the industry. The present session had been remarkable for the Branch. They had had one of their Past-Presidents as President of the Institute. The 1937 Convention was held at Derby, and, thanks to all who had subscribed to the appeal, so ably carried through by another of their Past-Presidents, Mr. S. H. Russell, and thanks to the civic authorities and the active support and co-operation of Derby's first Lady Mayor, the Conference had been, he ventured to say, as successful as any in the annals of the Institute.

Presentation to Mr. Gale

Mr. Evans said the Branch were indebted to their secretary, Mr. B. Gale, for his services, and he knew that all the members hoped he would remain the secretary as long as possible. Mr. Evans then made a presentation to Mr. and Mrs. Gale in appreciation of their services.

MR. A. E. PEACE (Past-President of the Branch), proposing the toast "Our Guests," said that it was the first Branch dinner at which the members had been favoured by the presence of the ladies. They were particularly pleased to have with them the Deputy Mayor of Derby, Councillor Mrs. Petty. The Branch members, and even their friends from the other Branches, knew how much they owed to Mrs. Petty for her assistance during the last Conference. There was also with them Prof. Wortley, Principal of the University College, Nottingham.

That year, during his term of office, Mr. Bigg had had multifarious duties, which had taken him away from the district. With great sincerity they welcomed him home. In mentioning the general secretary, Mr. T. Makemson, Mr. Peace did not think the Branch had held a dinner without Mr. Makemson being present. It was particularly gratifying to have friends in the Institute present from Lancashire, London and Birmingham, and it was delightful to have the ladies present.

COUNCILLOR MRS. PETTY, J.P. (Deputy Mayor of Derby), responded on behalf of the guests.

The dinner was followed by dancing, Mr. C. H. Smith acting as M.C.

Melting of Cast Iron in the Foundry*

By S. E. DAWSON, F.I.C., A.M.C.Tech. (The Stanton Ironworks Company, Limited)

In view of the many grades of cast iron which are available in the engineering industry to-day, it is not surprising that alternative methods of melting have been introduced into the foundry. The selection of an appropriate furnace is not entirely controlled by the cost of the melting operation, but may be more influenced by the type of metal concerned, and the tonnage and rate of supply required.

A continuous supply of ordinary grey iron, for example, is most economically produced in the cupola, but a small intermittent supply may be more conveniently produced in a crucible furnace. Alloy cast irons of high melting point, and containing more special elements than can be added in the cupola or ladle, require an electric furnace or open-hearth type of furnace where high temperatures can be produced and maintained where necessary. Other factors which may have to be taken into consideration might be purely local, such as the availability of a special supply of fuel or raw material.

It is useful in the first instance, however, to examine the operating and melting costs in each case, apart from any merits which may be attributed to a particular type of furnace. Whilst it is difficult to give exact comparisons owing to each type being generally of different capacities and melting rates, the following may be taken as approximate figures for such sizes as are in common use:—

Cupola	12s. to 17s. per ton.
Crucible	55s. to 90s. per ton.
Rotary, coal fired ...	16s. to 18s. per ton.
Rotary, oil fired	20s. to 28s. per ton.
Electric furnace	50s. to 60s. per ton.

[After discussing the cupola along the lines of his recent Paper,† Mr. Dawson then dealt with the crucible furnace.]

The Crucible Furnace

The cost of melting iron in a crucible melting furnace is considerably more than in other types of furnaces, because the heat is not put directly on to the metal, but has to be transmitted through the wall of the crucible. Where coke is used the fuel ratio is little more than 1:1.

The main advantage of this type of melting is the accuracy with which special compositions can be obtained, since there is practically no oxidation and the metal is free from fuel contamination.

Where expensive alloy irons are to be made this comparative freedom from oxidation is also worth consideration in the final cost of the metal, since losses from this cause may be from 10 to 30 per cent. in the case of certain metals. In some cases the crucible furnace is used as a superheater only, the cast-iron base metal being melted in a cupola and transferred to the crucible to be held and used as required, or to which ferro-alloys may be added if required. Where forced draft is used, this is only at very low pressure.

To avoid re-fuelling as far as possible during a melt (when the metal temperature would fall) adequate fuel space is necessary. A melt of cast iron in a crucible furnace takes from 2 to 3 hours, depending on the character of the materials charged, and the number of heats from one crucible is generally from 20 to 35, again subject to the above proviso.

Certain variations of the structure of cast iron (apart from analysis) are obtained, depending on the order in which the raw materials are melted or added. For example, steel will tend to refine the graphite if added to molten cast iron, whilst ferro-alloys will have the well-known inoculating effect in coarsening the graphite if added prior to pouring, though if added with the raw material this does not apply, since the graphite is again taken up during the superheating period.

It may be of interest to observe the effect of adding ferro-silicon (in small size) to a melt of low-silicon iron where a grey fracture is required with such a composition. Generally speaking, this effect is more marked where the raw materials themselves would produce a white iron, and is not so apparent in coarsening an otherwise close-grained grey iron.

Rotary Furnaces

As the name suggests, the rotary furnace consists of a horizontal barrel, capable of being rotated. The metal is melted by heat produced above the bath to which it is conveyed by the rotation through the medium of the refractory lining. By a suitable balance of heat input to refractory storage capacity, a concentration of heat can be obtained round the bath to give a high temperature to the metal. A general layout comprises the furnace body, waste gas flues in which may be situated a preheater for the air, and a fuel supply outfit.

The furnace body consists of a horizontal refractory-lined cylindrical steel shell mounted on four rollers and rotated through a chain or friction drive by a motor and gear box. Suitable electrical controls permit the furnace to rotate at a slow continuous speed during melting, and to be "inched" round when tapping.

Oscillation only is sometimes employed whilst the charge is still unmelted in order to avoid undue damage to the lining by pig-iron, scrap, etc. The furnace body, the overall length of which is generally about 2½ to 3 times the diameter of the shell, is tapered at both ends and the metal bath is situated in the centre. One end, into which the fuel is fed, serves as a combustion chamber, and the other as an outlet for the products of combustion, which pass down and along flues to a chimney stack, giving up their heat *en route* to the ingoing air for combustion through a tubular or other suitable preheater or regenerative system.

Two tapping holes are usually provided, one on either side of the furnace body, to obtain more even wear on the lining by their alternate use. The heat produced from the fuel introduced at the combustion end of the furnace raises the refractory lining to a very high temperature, which is transmitted during rotation directly to the underside of the metal bath by actual contact, with the result that the time of melting is reduced to about half that of a stationary furnace.

Such direct transference of heat to the bath overcomes the thermal insulating effect of the slag layer, which, moreover, protects the metal from undue oxidation and contamination by gases, etc. It is found in practice that a suitable mass of refractory for heat transference is obtained by a lining thickness of about 2 in. for each foot of shell diameter.

The charging is effected at one end of the barrel, and may be carried out by some form of charging machine, or the furnace may be tilted around trunnions to an angle of about 50 deg., the open mouth thus coming level with a platform or stage to permit charging as in an ordinary cupola. Further tilting to the vertical position for relining is also provided for.

Fuel Consumption

Rotary furnaces may be fired with either oil, pulverised coal, or gas. The fuel consumption is generally about 15 to 20 per cent. of the weight of the metal melted, inclusive of heating from the cold, emptying and slagging the furnace and running at least three melts a day.

Where oil is used, this is of the fuel-oil type with a specific gravity of about 0.92, viscosity about 100 Redwoods, and works out at about 45 galls. per ton. To maintain a constant pressure to the burner, the oil is supplied from an elevated service tank fed from the main storage tank.

Coal Preparation

Where coal is the source of heat, this is in a fine pulverised condition, and the kind used depends upon the type of furnace to be operated. In the closed type, where all the primary air is supplied with the powdered fuel, the mixture passing through and burning on a grid, somewhat on the principle of the gauze on a Bunsen burner, anthracite or semi-anthracite coal is used, but where complete combustion relies on a source of secondary air entering round the burner as in the open type, the coal may be of a bituminous soft quality. It is prepared in a suitable crusher and led to a hopper, from the bottom of which it is fed by means of a worm into the air stream and thence into the burner. Where several furnaces are in operation as a battery, a central mill delivers the coal supply to the hoppers in rotation, or as required.

The speed and efficiency with which powdered coal burns depends mainly on the size of the particles, the temperature of the mixture of air and coal, and the percentage of volatile constituents present. For a given size of particle, the other two factors are dependent on each other, and for immediate ignition as required in the rotary furnace the following are the relative conditions for a range of pulverised coals normally available:—

7 per cent. volatile in the coal requires 550 deg. C.
10 per cent. volatile in the coal requires 460 deg. C.
13 per cent. volatile in the coal requires 400 deg. C.
15 per cent. volatile in the coal requires 330 deg. C.
18 per cent. volatile in the coal requires 260 deg. C.

Bituminous or soft coals will, of course, burn at once with cold air. In a rotary furnace, therefore, where the heat in the waste gases is not utilised, only soft coals can be used.

The flame temperature, about 2,000 deg. C., is, however, almost independent of the volatile content. These temperatures relate to coals which have been so pulverised that 75 to 85 per cent. will pass through a 200 mesh, a degree of fineness imposed by the practical limitations of economic production. Beyond this degree of fineness the above temperatures or the volatile contents could be reduced and still give immediate ignition.

The appropriate air temperature is maintained by means of control dampers in the flues, and once the dampers are set for such conditions, the position of the flame relative to the burner or grid tends to adjust itself to the position as set, a flame burning too far along the furnace producing high flue temperature, which raises the air temperature and therefore speed of ignition, and automatically withdraws the flame again to the burner or grid.

In starting up from cold a furnace designed to use anthracite coal, the appropriate temperature of the air must be secured by the initial use of soft coal, which is gradually replaced by the hard coal as the temperature rises, and the hot exhaust gases pass through the preheater, an operation taking about half an hour. For obtaining the highest flame temperature, the ash content of the coal should be reasonably low, say below 6 per cent., to avoid absorption of heat in raising the particles to incandescence.

To facilitate crushing, as well as for economic reasons, the moisture should be as low as possible, and, if necessary, a drier installed between

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* Extracts from Paper read before the East Midlands Branch of the Institute of British Foundrymen, Mr. W. T. Evans presiding.
† "Cupola Practice," FOUNDRY TRADE JOURNAL, January 27, p. 97.

the coal bunker and the pulverising mill, so that moisture is reduced to about 2 per cent.

The close control and intimate admixture of both the air and fuel supply allow a near approach to the theoretical combustion, so that a minimum oxidising atmosphere can be maintained in the furnace. The amount of air required, for example, to burn both the carbon and volatile matter in average suitable coal is 135 to 140 cub. ft., or about 10½ lbs. by weight, and any excess over this absorbs heat from the flame and should be avoided.

Combustion Conditions

The character of burner employed depends on the type of fuel used, and in each case these have been developed to a high degree of efficiency by the various makers concerned. The air preheater or recuperator, situated in the exhaust flue, is generally of the tubular type, the tubes themselves being made of specially-treated steel to withstand the temperature obtaining in the flue and waste gases.

Appropriate gauges for recording the air temperature and pressure are installed to allow constancy of operation and efficient working of the furnace.

Rotary Furnace Linings

The selection of a suitable lining for the rotary furnace has been the subject of much thought and experiment. The conditions are more severe in this type of furnace than in the cupola, not only on account of the higher temperature attained, but also due to the more direct contact between the molten metal and the refractory.

Whether bricks or a rammed monolithic lining be used, much care has to be exercised in their application in the furnace to meet such conditions, and since thermal expansion occurs in all siliceous refractory materials, suitable provision must be made to allow this to take place, both gradually to avoid spalling, and within the mass of lining itself to avoid damage to the shell of the furnace.

In brickwork the joints should be given special attention for this purpose, and fritting over the surface of a new lining with sand or other siliceous material is to be recommended. In monolithic linings, internal expansion can be largely provided for by a suitable density of material, as controlled by the degree of ramming and the moisture content.

Many ganisters have been recommended for use in the rotary furnace with varying success, and whilst an ultimate composition of about 88 per cent. silica, 8 per cent. alumina and 1 per cent. oxides, with loss on ignition as balance, seems to be the desirable basis, the number of heats given by such a material is influenced by the physical characteristics, such as grain size and the type or nature of the clay present.

A suitable density to avoid undue internal disturbance during fritting and in service is about 2.3. A suitable moisture content is 6 to 8 per cent., preferably added on site to the dry material as received, by sprinkling water through a rose on to successive inch layers until the desired quantity of refractory is laid down. After leaving to mature for three or four days, suitably covered to avoid evaporation, the mass is cut sectionally and relaid in a similar manner, water being sprinkled on between each 2 in. layer. Further maturing for a few days should be allowed before use, when almost maximum strength will be attained.

Ramming Conditions

Some little experience is necessary to ram to the desired density, and it is generally advisable to feed the material under the rammer somewhat lighter near the shell of the furnace to allow expansion to be taken up if necessary, and to facilitate the passage of steam to vent holes provided in the shell. The internal shape and size of the lining are controlled by sectional formers, suitably bolted where necessary to permit removal of parts in use.

After air drying, the lining is dried by hot air or coke, an operation to be extended over several days or longer if possible. To avoid undue haste in these operations, the provision of a spare or duplicate barrel is desirable. Initial fritting of the lining prior to use for melting should be as slow as possible in order to avoid spalling and possible internal disruption. Such precaution is specially important up to about 500 deg. C. when the main expansion has taken place.

The general wear of a lining in service can to some extent be made up by repeated additions between heats of siliceous or powdered recovered refractory, but where more localised holes or depressions are concerned, patching with new material is necessary after chipping out to ensure good contact and substantial thickness, well keyed at the outer edges of the patch.

Life of Linings

By careful attention to the foregoing points it is possible to obtain as many as 300 heats from an individual lining when melting grey iron, although, owing to the many factors involved, an average of 200 to 250 may be considered good practice. Where higher temperatures are concrened, as in the melting of malleable cast iron, this number is somewhat reduced, and where steel only is melted, may fall as low as 20 or 30.

Up to the present, acid linings only have been used in practice, although some attention has been given to the possible use of a basic lining, suitably insulated from the greater heat conductivity.

Rotary furnaces are made in sizes of 10 cwts. to 15 tons capacity, and a close study of the size and rate of production of moulds must be made before the size of melting unit or units is decided upon.

Compositional Adjustment

It should be realised, however, that one metal bath can be made to serve for a variety of grades of castings, even including alloy admixtures, by the successive addition of silicon, manganese, nickel, chromium, etc., between successive tappings from the furnace. Carbon may also be added to the bath in predetermined amount by the use of suitable coke or carbon, when an efficiency of 40 to 50 per cent. may be obtained.

On account of the higher temperature attainable in the rotary furnace, all classes of ferrous materials can be melted, including grey and malleable cast irons, special alloy cast irons, and various grades of steel. Comparative freedom from contaminating gases allows considerable scope in the choice of raw materials, steel and cast-iron borings becoming available as ingredients of the charge. When exact precision in analysis is required, as for example in chilled rolls, steels, wear-resisting castings, and alloy irons, the metal can be held in the furnace whilst being sampled and analysed prior to making final adjustments in composition which may be found necessary.

By virtue of the rapid transference of heat from the furnace wall direct to the metal bath, the melting time is considerably less than in a stationary furnace similarly fired.

Exclusive of the first heat from a cold furnace, metal may be tapped in about 2¼ hours after charging, varying from 2¾ hours for malleable tapped at 1,500 deg. C. and 2 hours for grey iron at 1,450 deg. C. Low-carbon irons and steel may take rather longer, and oil firing tends to reduce these times. To the first heat an additional time of about one hour must be added for heating up the lining and flues.

Electric Furnaces

Electric furnaces may be classified into three groups, namely:—(1) Arc furnaces—direct and indirect; (2) induction furnaces, normal and high frequency; and (3) resistor furnaces, crucible and radiant. Except in a few special cases, the induction and resistor furnaces are not used for the melting of cast iron, and reference will therefore be confined to the arc types only.

Direct Arc Furnaces

In the direct arc furnace vertical carbon electrodes are suspended over the bath of metal contained in a bowl-shaped hearth, supported in a mild steel shell, the electric current actually flowing from the tip of the electrode through the bath. The three-phase type of furnace using three electrodes is generally used. The furnace is kept stationary during the melting period and is tilted forward for slagging and pouring. The roof is usually domed, and is made removable to enable repairs to be made to the lining. In striking the arc, the electrodes are lowered on to the bath by a suitable winch or hydraulic ram arrangement, which may be automatically or hand controlled.

Indirect Arc Furnaces

Of the indirect type, the rocking arc furnace is the one usually used for melting cast iron. It consists of a horizontal barrel similar to the rotary furnaces described earlier, with two or three electrodes entering through the ends on the horizontal axis. These strike the arc in the centre of the furnace independently of the bath.

The furnace is capable of being rocked through an angle of about 200 deg. C., so that new surfaces of refractory are exposed to and pick up the radiant heat from the arc, thus giving a quicker melting rate than in the direct type of furnace.

The heavy portions of the charge are placed below the level of the electrodes, which are temporarily withdrawn, though light swarf can be placed above the electrode level. The door is tightly sealed before the arc is struck for melting. The angle of rock is gradually increased as melting progresses, and pouring is effected by "inching" round, as in the rotary furnaces described.

Where the electric furnace is used as a duplexing unit, or as a superheater of cupola-melted metal, the current consumption is considerably reduced, and such a system permits of additions of steel scrap or other materials to the bath to adjust to a desired composition.

Changes during Melting

The changes in composition during melting in most types of furnaces depend somewhat on the efficiency of operation, and also on the character of the raw materials to be melted. In the cupola furnace, and using average normal charges, the loss of silicon is about 10 per cent., though this tends to be higher as the scrap in the charge is reduced or as steel is introduced. Manganese losses may vary from 15 to 20 per cent., whilst sulphur may increase from 20 to 40 per cent., depending on the quality of coke used.

The effect on the carbon depends on the original carbon present in the raw materials, and on the conditions of operating. The carbon always tends to attain the eutectic composition, that is, the iron will absorb carbon if below this figure, and lose carbon if above it. The extent to which this will take place is modified or delayed depending on the speed of melting, and whether the conditions due to air supply are oxidising or not.

In the rotary furnaces the silicon losses are between 10 and 20 per cent., manganese 10 to 15 per cent., and carbon 7½ to 20 per cent., depending on the nearness to neutrality of atmosphere at which the furnace is operating. The higher loss figures are usually associated with oil firing unless great care is taken in the control of the air to fuel ratio.

In the electric furnace, with ordinary precautions, the losses are only slight, since the elec-

trodes tend to retain a neutral or even a reducing atmosphere. In the crucible furnace, owing to the closed nature of the bath, the losses are almost negligible.

DISCUSSION

Mr. W. T. Evans (Branch-President), referring to the cost of coke, said it had varied considerably during the past year or two, and it would be helpful if Mr. Dawson could give some figures showing how he arrived at the costs given.

Mr. Dawson said he had taken present-day prices. He had taken the price of 48s. per ton for coke, but realised that some firms would pay more, and others less. For coal he had taken 36s. per ton and 40s. for anthracite coal, giving an average of 38s. When using anthracite coal, one had to always start up with bituminous coal. Having got a flame operating, after about a quarter of an hour, one changed over to anthracite coal. He had taken ¾d. per unit for current. The crucible furnace he took corresponding to the rate of the cupola.

Replying to Mr. P. A. Russell, Mr. Dawson indicated that his costs included everything except the metal cost; labour, fuel, depreciation, etc., were all included. For the cupola he had taken a medium size, such as was in general use. He agreed that very large cupolas would give different results.

Melting Rates

Mr. Russell queried the melting rate in the cupola as given by Mr. Dawson. To work a cupola fast, he thought one really had to overblow it, and in his opinion overblowing was harmful in cast irons of engineering quality. He personally worked to a figure of 10 lbs. per sq. in., and if a cupola would work at that rate, he considered it was working efficiently. If the scrap or any material used were rusty, then the melting losses would increase and that statement applied to any furnace.

Mr. Dawson said he did not altogether agree with Mr. Russell regarding overblowing. He used to consider 10 lbs. per sq. in. as a good melting rate per hour. When he increased the melting rate—which Mr. Russell wrongly, he thought, called overblowing—he found he had not failed to produce better metal for the particular purpose. If one ran with too high a coke ratio, up to 16 to 1, there was excessive contraction, which could be overcome by altering the method of running the casting.

The Pitot Tube

Mr. A. E. Peace referred to the question of Pitot tube readings. It was necessary, he said, to section the pipe, and the usual practice was to split the pipe into a number of annular rings of equal area, and to pass a line through the pipe on opposite diameters to arrive at the correct position of insertion of the Pitot tube. He found the tube should be inserted for a depth of one-third of the pipe diameter, which Mr. Dawson confirmed. He asked Mr. Dawson if he had any ideas upon the thickness of lining, apart from what he gave in the Paper. He had in mind that the thickness of lining would have an effect according to the number of hours the cupola was worked. The question of conductivity seemed to depend appreciably on that. He had not heard of anyone experimenting by insulating the cupola lining. He did not understand the use of old firebricks, and asked how they should be used, whether in lump or as a "grog."

Mr. Dawson agreed that the method outlined by Mr. Peace for the Pitot tube was unquestionably the best. The cupola lining generally adopted, which was often the result of previous practice, worked reasonably well. The construction varied from one foundry to another, some using thick and some thin linings. In a rotary furnace, an insulating layer was necessary. The old firebrick was simply used in the brick form and not crushed. The old brick would stand up better than ganister and moreover they were cheaper and could generally be used up to two-thirds the amount of ganister.

Case of Small Cupolas

Mr. J. C. Hallamore said the Branch had discussed cupola practice at a previous meeting. He had mentioned a 20-in. diameter cupola, which he was told was not a cupola. The point which had particularly interested him was the figure for the amount of iron charged in the furnace. The figure was given in all books, and he would like to know if it represented actual practice. From the figure given, the amount of metal in the stack should be equal to the melting rate for an hour. Taking a 20-in. diameter cupola, one could melt 25 to 30 cwts. in an hour, and get up to 12 cwts. in the stack. Should one double the size of such a cupola?

Mr. Dawson said that the small size was still a cupola, but he had been referring to cupolas would would meet average requirements. The figures given referred to average-sized cupolas. About an hour's charging gave the height of charging properly to absorb the gases.

Mr. R. H. Buckland expressed interest in the German type of cupola, in which the waste gases were used to pre-heat the air used for blowing. The waste gases were extracted from the cupola several feet from the top of the charge. Was not this taking away heat that should preheat the upper charges? Mr. Dawson had given a brief description of coal crushing. He appeared to use a circular steel barrel, in which manganese steel rollers were used for crushing the coal. If that was the correct description, what size were the holes in the barrel, and what size of coal was obtained from that crusher? The Paper had included a very good description of rammed linings for rotary furnaces. Had Mr. Dawson any experience of brick linings?

Mr. Dawson observed that if there was sufficient hot air to heat up the cold blast, then the cupola was not being run in an efficient manner. He preferred a different arrangement, whereby the air was heated from an independent source. Regarding the crushing of coal, the barrel was perforated to a fine mesh, with a space of about 2 in. between each hole. He had omitted to state that the coal had to be reasonably dry, or it would cake. About 2 per cent. of moisture was the maximum that should be allowed in coal.

Silica Bricks as Cupola Linings

He had had a good deal of experience of brick linings, and the silica bricks gave much the best results. Much care had to be taken in placing the bricks; they had not to be put too close. A good practice, when using bricks for lining, was to ram a 1-in. thick backing of ganister, to allow for expansion of the brickwork. Quite a number of special bricks were required to get round the corners properly.

Mr. Dunleavy asked what were the advantages of the receiver used by Mr. Dawson, apart from the saving of coke. The lecturer had told them that the gases from the coke, as they ascended in the cupola, contaminated the metal as it was descending. In his opinion, some steps should be taken with the manufacturers of the coke. Could not the coke be treated in some way to eliminate the undesirable gases?

Mr. Dawson pointed out that the receiver did not save coke. All one did was to take the metal from the well of the cupola, and prevent its contamination with the coke and slag on top of the iron by tapping it off into a receiver. In the cupola, the gases referred to were those produced by the burning of the carbon. Coke was made in various qualities, depending on the coal from which it was made, and it was economical to buy a coke with a low ash content.

Vote of Thanks

Mr. Bunting, in proposing a vote of thanks, recalled that Mr. Dawson had had much experience with various types of furnaces, which very few were able to get, and that he spoke from practical experience. He had much pleasure in proposing that best thanks be accorded Mr. Dawson for his Paper.

Mr. Goodwin, in seconding, said that he had found from cupola practice that, if aiming at an iron with about 1.3 Si, 0.2 Mn, 0.02 per cent. P, and starting with a T.C content of about 1.3 per cent., one would actually get anything from 2.4 to 2.6 per cent. carbon in the resultant metal.

Mr. Dawson, after thanking his audience, said he would not like to melt a 1.3 per cent. carbon iron in a cupola; if held long enough, it would eventually increase in carbon by pick-up from the coke.

A Sidelight on Sand

By A. I. Wynne-Williams, A.M.I.Chem.E.

The structure of wind-blown grains of sand is instructive. The sand dunes of the Libyan Desert, which owe their formation entirely to the action of the wind, are continually in movement. The shape of the dunes and their conformation relative to each other are definite and regular. The height, angles of slope and distance from crest to crest have an almost geometric exactness.

The surface of these dunes possesses a property which shows that the mass of each dune, which is built up entirely of sand grains of approximately uniform size, has a definite structure. The surface is so weak that a survey pole can be pushed down into the sand with one hand and will not remain upright for long; but, provided that the surface layer of sand is not disturbed, a motor-car can be driven over it without sinking. That this is not purely a question of pressure per unit area is shown by the fact that if the surface layer of sand is disturbed, as, for instance, by walking upon it, the tyre of the car will sink at the point where disturbance has taken place. In the undisturbed state the sand surface will bear considerable pressure normal to the surface, but once the surface layer has been disturbed either by excessive pressure normal to its surface or by displacement of the surface grains, it is barely capable of supporting any weight and behaves as a liquid.

There is no crust or apparent lateral adhesion between the surface grains, and the strength of the undisturbed surface must be due to their arrangement relative to each other. The grains which compose the dune must conform to a definite structure.

The dunes are in movement. The sand is being removed continually by the wind from the windward face, and deposited on the leeward face, but the rate of movement varies with the strength of the wind, which passes through a cycle every twenty-four hours.

It was found that, under average conditions, a surface which had been mechanically disturbed did not heal, that is to say would not bear weight again, for several months.

Application for Duty on Imported Pig-Iron

The Import Duties Advisory Committee give notice of an application for the removal of pig-iron from the free list and the imposition of an additional import duty on pig-iron, other than pig-iron smelted wholly with charcoal and vanadium-titanium pig-iron produced in an electric furnace. Any representations which interested parties may desire to make in regard to the applications should be addressed to the Secretary, Import Duties Advisory Committee, Shell-Mex House, Strand, London, W.C.2, not later than March 24.

Machine-Cast Pig-Iron

SHEFFIELD FOUNDRYMEN'S APPROBATION

At the February meeting of the Sheffield Branch of the Institute of British Foundrymen, a Paper on "Machine-Cast Iron" was read by Mr. J. C. Jones, of the Workington Iron & Steel Branch of the United Steel Companies, Limited. This Paper was published in the February 24 issue of the JOURNAL.

MR. J. ROXBURGH (immediate Past-President) occupied the chair, in the absence of the President (Mr. J. B. Allan) who could not attend. Expressing the members' indebtedness to Mr. Jones, Mr. Roxburgh said the lecture had been most instructive, and he would also like to associate with those remarks Mr. Swan, whose film was indeed excellent and had definitely added to the interest of the meeting.

Mr. Roxburgh said the members would have realised, as Mr. Jones had pointed out, that there were certain advantages with regard to "machine-cast iron," though he did not really know why Mr. Jones objected to calling it "machine-cast pig-iron," for the latter phrase, in his opinion, was just as suitable. Foundrymen appreciated that, when casting pig-iron on to sand beds, there was definitely a variation in analysis in different parts of the bed, and that by mixing the iron in some suitable ladle before pouring the analysis was bound to be more constant. It was appreciated also that machine-cast pig-iron was cleaner, due to the absence of sand. At the same time, he wondered if any members had had experience of the melting of machine-cast iron. Mr. Jones' remarks with regard to the reduction in the amount of limestone that was used, and also the reduction which he claimed in regard to the cost of fuel, were of real importance to foundrymen, and he asked if any member had had experience in regard to those two matters.

Retention of Close Grain

Another interesting point which arose from the lecture was with regard to the quality of the new product. As Mr. Jones had said, the product obtained was more close-grained than that obtained by casting into sand beds, and foundrymen would like some evidence to prove that this structure was retained on remelting, thus improving the resultant casting. Another point of interest was the question of the actual pig moulds. He wondered if Mr. Jones could indicate how long those particular castings lasted, because he had mentioned that from time to time they were broken. Could he indicate where the breakages occurred, and whether it was the lugs that were broken off or the actual mould itself cracked in service? Had he ever thought of making these lugs of, say, mild steel cast into the pig mould? No doubt the use of the pig-casting machine in the production of pig-iron was being extended, so it behoved the foundryman to become acquainted with this new development.

A Question of Nomenclature

MR. JONES, in reply, said that if the iron were satisfactory to the user, it did not really matter whether it was called pig or slab iron. The question of whether the iron retained its close grain and other characteristics after remelting was rather a momentous one, which had been discussed time and time again. He would like to draw attention to the evidence of numerous foundrymen, who were probably more qualified than he was, through their practical experience, to settle this point. The fact that they insisted on being supplied with close-grain iron was, he thought, a sufficient answer that its influence did prevail. Bound up with that was the possibility that there were other influences beside its chemical analysis, such as body, timbre and other characteristics, known as inherent or hereditary properties, which were perhaps not yet fully understood.

Life of Moulds

With regard to the moulds used on the casting machine, they had not yet tried the arrangement Mr. Roxburgh described. They did try some moulds with a low-carbon composition, but these moulds gave shorter life through cracking troubles. The best composition they had obtained was that used for hematite ingot moulds. They had not experienced much trouble with breakages at the lugs, and any cracking was more likely to occur when the casting machine was starting up, the mould pans then being on the cold side. By keeping to the ingot-mould analysis, they obtained a good service life of the moulds.

MR. R. C. TUCKER, after expressing his appreciation of Mr. Jones's lecture, thought he might claim to be the instigator of the meeting, because the question of discussing machine-cast iron occupied about three-quarters of the discussion of a Paper which he gave to the Branch the previous session, and it was decided at that meeting to invite the Workington people to tell them something about it, because it was understood that they not only made it, but also used it in their own foundries, and therefore should be qualified to give some information about its qualities.

"Piger" Iron

One amusing thought occurred to him with regard to the derivation of the term "pig" iron. Mr. Jones had said that it appeared like sucklings at a sow. That was perhaps rather obvious—too obvious in a way—because they knew that the main runners of a pig bed were called sows. But if they went back a little further, they would remember that cast iron—or should one say pig-iron?—i.e., molten high-carbon high-silicon iron, was first made, in Europe, in Germany, in a strange baby blast furnace called a Stückofen. This was about A.D. 1400, or perhaps earlier. Previous to that, with a 10 ft. or 12 ft. furnace, when they got a molten product at all, it was white, and therefore steely in fracture; but, when they put the inverted cone on top, they started to get what was now called grey pig-iron, but which, in comparison with the silvery iron that they had previously had, was definitely black.

The Latin word for black was "piger," and when descriptions of the process were written by the monks, in Latin, which was the language of educated people in those days, they called this grey iron "piger" iron. That was quite a definite term in mediæval metallurgical literature. He thought that the name "piger iron" came from Germany to this country, that it was probably known as "piger" for short, and that from that came the agricultural simile of the big ones being called sows.

The Case of Hematite

He presumed that blast-furnace owners did not put in a pig-casting machine to help the foundryman to melt his iron more cheaply. They put it in for the reason that Mr. Jones had told them—lack of pig-bed room with increased output—but, he presumed, mainly because it was cheaper to cast off a casting machine than to employ a squad of men moulding pig-beds. He also presumed that at Workington there were very favourable conditions for the handling of machine-cast pig-iron. For one thing, they had a battery of furnaces of high output, and therefore they could carry the capital cost of a pig-casting machine; secondly, the iron that they were using was about the least liable to change in structure of any iron in the country, namely, hematite. According to the analysis that they saw, it was a 2 or 2½ per cent. silicon hematite. It was rather difficult to chill that off except in very thin sections, and so Workington would not have any difficulty in dealing with buyers. Working grey pig-iron, whether close grained or not, did not really matter—it was still grey.

Seeing that the graphite nucleus theory had been pretty thoroughly exploded, he could not see the structure of this iron, which had been artificially modified by rapid cooling, chilling from below and quenching from above, being profoundly modified in the casting. In any case, as it was a hematite pig-iron, it would be very difficult indeed for anybody to detect any difference in the behaviour of castings made from it.

There were other pig-casting machines in the country, and it would be very interesting, as machine-cast iron spread to industry, to find out if there was any alteration, particularly in the higher phosphorus varieties, and those higher in sulphur and lower in silicon, because those were the irons that one would expect to show up mottled if machine cast rather than sand cast.

Silicon Variation

Cleanliness of the iron was a very great feature, but he thought the greatest advantage of machine-cast pig-iron to the foundryman was its uniformity. In his own Paper he had shown the variations in silicon analysis for a typical week, and actually found much greater variations than Mr. Jones had shown. Mr. Jones' blast-furnace practice was very good indeed, because he graded and sized his raw material, which very few furnaces in this country did to-day. He would like to see all ores being graded, screened and crushed before use, and he could understand that, after the ore had been through the mechanical treatment, it must be an ideal blast-furnace burden, and therefore the furnace must work very uniformly, compared with the unsized ore practice which was so common in this country. Therefore, Mr. Jones had probably shown, in regard to the silicon variation, the best conditions for sand-cast pig-iron. All foundrymen could endorse that the variations in silicon, in even one truck, could be quite considerable in sand-cast practice. He knew, from his blast-furnace experience, that variations of 1 per cent. from the top to the bottom of a cast were not uncommon, and, therefore, blast furnaces using unsized ores and somewhat more irregular working did make a practice of sampling their casts at least two and sometimes four times from a 30- or 35-ton cast, and analysing each sample for silicon, and then the different parts of the cast were stacked for various customers. Obviously, there were times when the particular bed changed over from one analysis to another, an error might occur, and a foundry might receive an odd bed in the truck which did not belong to that part of the cast. That was where disputes in regard to silicon arose between the producer and the user.

Cupola Economies

He was very interested to know that there was 1 cwt. coke difference in the cupola practice. That was a 15 per cent. coke saving, which was very considerable. It was more than was supposed to be brought in by the introduction of the balanced-blast cupola, and if they used such a cupola and machine-cast pig-iron they would be soon calling a cupola an air furnace!

He was very pleased indeed to see that at least one blast furnace in this country had all the modern improvements. There was only one quibble he had to make, and that was that they still used the double bell-type charger on the top of the furnace. The Federation had proved last year, in Papers by Professor Bone and Dr. Ward, that this bell-type charging did not per-

mit uniformity of distribution in the burden because of the size segregation that took place on sliding off the bell, which gave rise to intense heterogeneity in the blast-furnace stock. He thought Mr. Jones had overcome that somewhat by making all the ore one size at any one time, and it would be very interesting if these experiments of the Federation could be applied to a furnace of Mr. Jones's battery, using sized ore, to see the possible conditions obtained from that practice.

Ore Crushing and Grading

Mr. Jones expressed thanks to Mr. Tucker for his explanation of the origin of the definition "pig-iron." He himself had not been able to find any other explanation than the one he gave. He agreed that there were difficulties with low carbon-silicon irons. When casting special refined iron with 2½ per cent. carbon and 0.8 to 1.0 per cent. silicon, the rapid cooling tended to break the iron into small pieces, which might in some cases necessitate slightly different methods of handling. The 3.0 per cent. carbon, 2 to 2½ per cent. silicon, grades did not break up in this fashion. In all grades they obtained the uniform composition, and he was glad to hear Mr. Tucker stress this important advantage.

Regarding the ore crushing and sizing shown in the film, he agreed with Mr. Tucker that the ore lumps seen in the wagon were not abnormal for blast-furnace charging, but perhaps Mr. Tucker did not notice the amount of very fine ore. The fine ore was also screened and separated.

With reference to the reduction in coke consumption, the figures quoted were obtained from an ingot-mould foundry using about 100 per cent. machine-cast hematite iron charge, and the reduction would be more easily seen than in a foundry where about 20 per cent. machine-cast iron was used. Regarding the blast-furnace bells, it should be noted that the charge was mixed in revolving skips or hoppers before being charged into the furnace top.

Dr. Percy Longmuir (Past-President) said his mind had been carried back to the inception of the Institute, and in particular to Mr. Mason, now in Australia and one of the keenest foundrymen he had ever known. Mr. Mason had asked him (he was only a youngster then) if he had any idea of how much sand adhered to pig-iron as normally cast. He did not know. Following suggestions that were given to him, Mr. Mason gave a Paper which in later years appeared in the Proceedings of the Institute, a Paper in which Mr. Jones would be very much interested. Mason went to the trouble of wire-brushing several tons of iron, and then sweeping out the trucks; he based his results on an estimated weight of sand per pailful, and then correlated that with the necessary limestone.

All progressive foundrymen welcomed the new development, but it was necessary to give a word of warning—that the laboratory control must be keener than ever. He thought Mr. Jones would agree with him there. He had seen in various countries both machine-cast and sand-cast pig, and one's experience generally was in favour of the sand-free pig-iron.

Blaming the Pig-Iron

Mr. Jones's remarks in regard to the reduction of essential fluxes in passing through the control covered that point very well, and he would find confirmation of them in Mason's Paper. After all, not all foundries were wise enough to take advantage of chemical control. There was a recent experience in which a foundry was using 5 cwts. of good-quality pig-iron to 15 cwts. of bought scrap. They very naively said they could not estimate the quality of the scrap, and very few foundry chemists could estimate the quality of the bought scrap which was on the market today. He thought Mr. Tucker would agree that there was no known laboratory method of estimating the oxide in burnt scrap, and most of the scrap that went into some of the foundries was burnt metal. In the case he had referred to, the pig-iron was blamed, but he would call their attention to the fact that there were 5 cwts. of it to 15 cwts. of an absolutely unknown material.

Mr. Jones agreed that it was practically impossible to estimate the quality and condition of scrap, and, as Dr. Longmuir had stated, the scrap used was very often of greater weight than the iron, but it was usually the iron that was blamed for any trouble with the finished castings.

Mr. V. E. Upton asked if the size or shape of the pig moulds used at Workington varied from those used by other companies in this country supplying machine-cast pig-iron. Mr. Jones did not say that machine-cast pig-iron was easily stacked, but rather that there was no reason why it should not stack easily. His experience was that with the present shape of pig there was considerable difficulty in stacking this class of iron with safety. In fact, only recently a case had been brought to his notice where a man might have been killed through the movement of a stack. Apart from this, he found that where a firm had used machine-cast pig-iron it would not go back to any other type.

Stacking Machine-Cast Iron

Mr. Jones said he believed there was a different type of mould. The design of the mould as described in the Paper might not represent a final decision, and some design of a suitable shape which would stack better might be found in the future. It was necessary to have a mould designed to facilitate easy removal and rapid cooling of the iron. The manufacturer was alive to the fact that the customer was always, or nearly always, right, and tried to give him what he required. Certain designs caused "stickers" and "double-run" iron.

When they heard of the difficulties in handling and stacking machine-cast iron, it was of interest to note that no complaints appeared to be made regarding the physical condition of the scrap used, which, as stated by Dr. Longmuir, was in some cases as much as 75 per cent. of the charge. There might also be a more suitable mould wash instead of the lime wash now used. He did not know whether blacking had been tried as a mould wash, but these matters would no doubt receive attention.

Mr. E. Wharton, observing that Mr. Jones had opened his remarks by saying that he was going to show them what was a step forward in the manufacture of pig-iron, said it certainly was a step forward in the mechanical means of dealing with large furnace outputs. Not all foundrymen would agree, however, that it was a step forward from a foundry point of view. They had heard the case put forward for a specialised product, hematite iron. What was going to happen when this kind of thing was put forward for small-scale founders to use in the way of, say, higher phosphorus irons? The situation would certainly become more difficult. For a long time it had been accepted that control by fracture and analysis in grey-iron foundries had given the best results, and the product which was now being put forward would require a new technique in the way of ascertaining or arriving at what might be expected in the foundry after melting. Sand-cast pig did sum up for them visually what the various constituents might be expected to do for them when they put the product into a sand mould, and in general that was why the founder who had used the fracture and analysis method had been so successful.

One of the foremost features of improvement which the members had seen that night was the method of putting the whole of a cast of metal into a large ladle, and thereby getting uniformity. There was no doubt that, if that method could have been applied to sand-cast pig-iron, some very great benefits would have been derived in it from the founder's point of view.

A Simple Correlation Method

Coming back to the question of fracture, what was the small-scale founder, who had spent a lifetime with sand-cast pig-iron, going to do when he received this machine-cast article into his foundry? First of all, if he had not already been familiar with the compositional side of the business, he had to familiarise himself with analysis. He then looked round for something as a practical check, and he would have to do much experimenting before he arrived at the correct way of using machine-cast pig. There was a firm at the present time making pig-iron for general founders by the machine-cast method, and it was being found possible, although it had not been put out very widely, to supply to certain foundries a sample which had been cast in sand in the normal manner along with the machine-cast article, thus educating the foundryman in the way of using machine-cast pig.

Then again, the small-scale foundryman had to be considered with regard to the size of the pig used, because there were many founders who required small pigs—pieces considerably less than the ½ cwt. which they got in this particular case.

The speaker agreed that there undoubtedly would be a saving from the cupola point of view, and that machine-cast pig-iron would be better in many other ways of cupola practice. He did not agree with what Mr. Tucker had said with regard to the saving being equal to that obtained by using large balanced-blast cupolas. The balanced-blast cupola was put out to, and did actually, save 25 per cent. of coke on ordinary melts, though in the case given it was, he thought, 15 per cent.

Mr. Jones said Mr. Wharton had mentioned some difficulties from the users' point of view and at the same time instanced some of the advantages gained. Regarding phosphoric machine-cast iron, he could not see that there would be any difficulties. A certain works which manufactured phosphoric iron was at present installing a casting machine, and it did not anticipate any difficulties regarding the manufacture or use of the iron.

Machine-cast iron broken at the notch showed the fracture, which was in normal irons the close-grain structure desired by most foundrymen. By half filling the moulds and cutting out the notch a smaller slab about 25 to 28 lbs. weight was obtained. These pieces were not joined together as in the usual size, but came out as separate small pieces.

A User's Experience

Mr. F. Whitehouse thought it would be hardly fair if he did not say something of his experience with machine-cast pig-iron. Some years ago his firm used it rather extensively. They did so because they found in practice that it gave much better results than any other iron which they could buy to give them the same analysis in the final casting. The type of casting they were making at that time was of a high standard, and in particular they were making a quantity of wheel-blanks, which were some 5 ft. in diameter and weighed about 15 cwts. The trouble encountered with ordinary iron mixtures was that the ends of the arms, where they joined the rim, were not too good. By using machine-cast pig-iron of a certain brand, they overcame that difficulty, and if ever they slipped away from machine-cast pig-iron, even when they obtained the same analysis by other means, they again encountered trouble. Thus, from purely personal experience, he would say that machine-cast pig-iron did give something that they did not get by other means.

He would add that they used to melt at less cost, but they did not attribute that to the fact that the pig-iron had no adherent sand. They claimed that it packed better in the cupola, and for that reason they tended to get a better melting rate. They also applauded this pig-iron be-

cause it gave less slag. They were under the peculiar necessity at that time of needing to get in a ladle just about as much as the well of the cupola would hold, in one tap. It was necessary, in order to cast certain jobs; one tap, one bottom full, and accordingly excessive slag became a nuisance, so they selected machine-cast pig-iron for that reason.

The snag was that the iron was difficult to handle with a pair of tongs. It was the habit of the labourers who charged the cupola to pick up the pig-iron with a pair of tongs, and it was much easier to pick up ordinary pig-iron in that way. A second criticism was the one mentioned by Mr. Upton, that the machine-cast iron was not easy to stack. However, one forgot these things in the bigger advantages that were to be obtained, so he would pay that tribute to machine-cast pig-iron, though it was not Workington iron that they were using.

He would like to ask a question concerning the pig moulds that were used at Workington with the pig-casting machine. Were there any means, or were any means employed, of, so to speak, reinforcing these pig moulds by casting bar-iron within the pig mould? (MR. JONES: No.) He would also like to ask if the flow of metal was always directly on the notch As a manufacturer of pig moulds, he was interested in getting at the user's difficulties.

MR. JONES said he did not think they could work it so fine as that at the present time.

MR. WHITEHOUSE insisted that, in the main, it did drop on to the notch.

MR. JONES said he was glad to hear Mr. Whitehouse's statements regarding his experience of machine-cast iron. Referring to the fuel cost saving he had mentioned in the Paper, it was his opinion that this form of iron did give a quicker melting, and in addition to the saving from the sand point of view, the iron packed better in the cupola and did not "bridge" or scaffold like sand-cast pigs, thus giving increased production and lower fuel costs.

A Better Sand for Pig Beds

MR. T. R. WALKER suggested that there was no reason why the manufacturers of ordinary pig-iron, instead of selling sand at the price of pig, should not use a more refractory and a better sand, and give them pig without sand on the outside.

MR. JONES said they had discontinued manufacturing sand-cast pig-iron at Workington.

MR. WALKER, continuing, said he was not sure whether machine-cast pig-iron was suggested or recommended for acid open-hearth practice; but, assuming that it was, had anyone worked out the amount of silica necessary to form the melting slag? It had to come from somewhere, and if there was enough in the pig to form that slag, well and good; if not, it must come from the outside of the pig, the sand coating, or from the banks of the furnace, which would not be an improvement. He had not worked it out himself, but was asking for information.

MR. JONES said there were other sources, such as the scrap. He suggested it would be better to use clean iron and add a known weight of flux, rather than rely on an uncertain and varying amount of sand, as was found in sand-cast pig-iron.

MR. R. C. TUCKER said the use of superior refractories would add to the cost of the iron. He was sure Mr. Walker would quibble at the extra cost of using, say, sillimanite. If he would like to use synthetic sand, with controlled moisture, controlled grain size, and controlled refractories, there again he would run into quite considerable financial difficulty. The speaker thought that Mr. Jones' solution of the problem, by charging the pig-iron as 100 per cent. pig and then adding a known amount of silicon, would give even more uniform results in acid steelmaking. With regard to Mr. Walker's remark about selling sand at the price of pig-iron, surely he knew that there was an allowance of 2½ per cent. with regard to what dropped off? (Laughter.)

Mr. Wharton, he said, had raised a point about the balanced-blast cupola effecting a saving of 25 per cent. of coke consumption. He agreed that it might in some cases, if they had had very bad cupola practice and then decided to reorganise and instal the balanced-blast. If they had already got good cupola practice, he maintained that the saving by the balanced-blast was not more than 15 per cent.

Phosphoric Irons

MR. F. E. STEELE said the foundryman was often expected to make 99 out of 100 castings good, and it was very pleasing that the manufacturers of the materials which the foundryman had to use were at any rate moving forward in the direction of giving him as consistent materials as they possibly could. One must admit that the cleanliness of the machine-cast pig-iron must necessarily improve the finished product. He had been greatly interested by the questions that had been raised with reference to high-phosphoric irons, because he personally was interested in making castings of a very thin section which had to be machined all over. In making castings of this nature with machine-cast pig of high-phosphorus content perhaps he would get intense chilling, and especially when those castings had to be made in green-sand moulds; one had to be very careful in the manufacture of such castings that had to be machined, because of the chilling effect. That was one of the things that certainly did create anxious thought, as to what would happen in the manufacture of machine-cast pig-iron.

MR. JONES said he had pointed out that the blast furnaces had adopted a standard of uniformity in raw materials used, and had found it beneficial in producing a good iron, and it was equally important that the cupola melters should have uniformity in the materials they used. He did not think that Mr. Steele should have any fears regarding the use of machine-cast phosphoric irons. The phosphoric iron, mentioned in a previous answer, was chilled round the edges but grey in the centre.

Copper Moulds

MR. M. BROWN said that if he had charge of one of the machines for casting pig-iron, he would be very tempted to put into the chain of moulds half a dozen made of copper to see what the result would be.

MR. JONES said the suggestion was most interesting, and he would bear it in mind.

MR. WHITEHOUSE said Mr. Jones had remarked that machine-cast pig-iron was used extensively by foundries which made ingot moulds. Could he indicate whether the results with the ingot moulds were better or worse or unchanged from a foundry point of view, or from the point of view of using those ingot moulds?

MR. JONES said that in addition to a saving in fuel cost, there was a decided improvement in the life of the ingot moulds. He could not say at the moment whether that was due to the structure, composition or the uniformity. He thought the regularity in materials and practice had more influence on producing good castings than anything else. In his opinion moulds made from machine-cast iron gave better service.

MR. TUCKER thought that was in line with a recent experiment of the Cast Iron Research Association with the titanium-CO_2 process. They secured much finer graphite than could be obtained with the use of machine-cast hematite, and about 10 or 12 per cent. increase in life. That was not much, and one wondered if it was due to the extra care taken with the moulds in the steel-melting shop.

The CHAIRMAN asked if Mr. Jones had actually proved that there was a difference in the structure of the moulds themselves. Had he taken micrographs of the structure of the ingot mould as made from the machine-cast pig and from the sand-cast pig, or could he give any reason why the life should be improved by the use of this machine-cast pig-iron?

MR. JONES replied that the research department was investigating this point. The fracture-structure of the moulds appeared to be slightly finer in grain size.

Modified Mould Shape Suggested

MR. LEATHERLAND said that when there was a running stream of metal over a continuous line of moulds there was bound to be a flash, or a splash from one mould to another. Where did that metal go? Was there any possibility of its getting between the joints of two adjacent moulds and causing the possibility of "jamming?" Regarding the shape of the moulds, there ought to be some definite standardisation. The normal pig-iron led to piling up inside the cupola. They wanted pigs which were capable of being stacked safely and handled easily. Moreover, in order to get a longer life from the moulds, they should alter the shape. On the face of it, he would suggest a double figure 8 mould instead of what one might call the single figure 8 as at present. He meant a double figure 8 at either side of the breaking, but no breaking within, but in the centre of the 8 portion; in other words, they might have a double corrugated mould. He thought by doing that they would relieve the various stresses. They could do it with slag pans in an open-hearth furnace, which was a good form of receptacle of slag and would withstand high temperatures. Such slag pans at the works with which he was connected had given a life of perhaps ten years, largely due to the design, which was on the corrugated principle. One might aptly apply that principle to the moulds without greatly altering in shape or form the resultant pigs.

Copper moulds might be satisfactory, but he thought the resultant cost would be prohibitive. The moulds had to be replaced at some time. He was aware that there were wearing parts on the moulds, and he thought that the wear would defeat the object of securing the maximum life of the mould. On the other hand, Mr. Jones had not said definitely what the trouble was. He had mentioned cracking, and did that mean craziness in the internal surface; if it did, were those moulds withdrawn before they had actually broken down, or only when they broke down?

MR. JONES said cracked moulds were withdrawn immediately and replaced with new moulds at a convenient time. Generally there was but little trouble.

MR. LEATHERLAND: Do you get any trouble from fins due to cracks?

MR. JONES, replying in the negative, said the speed adjustments worked from the operator's cabin covered these points. The amount of spillage and splashings was very small. What little scrap made was composed of runner and trough metal.

MR. LEATHERLAND, referring to the lining of the moulds, suggested as an alternative to lime wash an inverted blacking spray, mastic varnish, or tar.

Vote of Thanks

MR. S. LEETCH proposed a vote of thanks to Mr. Jones and Mr. Swan, and DR. C. J. DADSWELL, in seconding, said that he had been hoping that Mr. Leetch would have told them of the results of a little talk they had during the discussion. They had decided that they could satisfy many of the critics who had spoken, particularly those who preferred the fracture of a sand-cast pig-iron, by introducing a continuous-casting sand-mould pig machine. As far as they could see such an arrangement would be quite possible but, of course, not necessarily economical.

Australian Foundry Practice and Enamelling Technique

Mr. W. Thomas' Paper on "Australian Foundry Practice, with Special Reference to Vitreous Enamelling,"* which was presented to a joint meeting of the London Branches of the Institute of British Foundrymen and the Institute of Vitreous Enamellers, created an excellent discussion, and elicited much information as to working conditions and technical details.

This discussion was opened by MR. V. C. FAULKNER (Chairman of the Southern Section of the I.V.E., and Past-President of the I.B.F.), who first thanked the London Branch of the I.B.F. for having invited the enamellers to take part in the joint meeting, and expressed the hope that the meeting would be the forerunner of other joint meetings in the future.

Sand Preparation

Discussing points raised in the Paper, he mentioned first the excellent deposits of dune sands available in Australia, and asked whether Bentonite or the equivalent was available there to mix with the dune sands in order to make synthetic sands. He also asked whether the Australian foundry industry exported its products to New Zealand, New Guinea, and other parts of the Antipodes.

Perhaps, he suggested, Australia was fortunate in respect of the conduct of its foundry and other industries, because it had not traditions such as those which held in this country and, therefore, could start free from prejudices with new processes. That absence of tradition had probably helped the Australian foundry industry, the development of which had been both remarkable and rapid. Inasmuch as the author had not referred to sand preparation, he wondered whether the Australian founders followed the practice of England and Scotland in allowing the moulders to prepare their own sands or whether the sands were prepared in a central plant at each foundry. If the latter were the practice, what was the nature of the sand-preparation plant? He believed a new sand-preparation machine was available which had not yet made its appearance on the English market. He asked also whether the perrets used at the works described in the Paper were made in Australia or whether they were imported from America or Great Britain. Finally, he asked for information as to the type of mills used in the Australian works for making enamel.

Import and Export

MR. THOMAS, replying to the question concerning the making of synthetic sands, said there were certain substances available in Australia which could be used instead of Bentonite; but for the work done so far Bentonite had been imported from the United States. There was a lot of export from Australia to New Zealand, and a certain amount to New Guinea, and that comprised pretty well all the export Australia could hope for in respect of its foundry products.

Australia was behind this country in respect of sand preparation. It was only quite recently that the survey of sands had been made, resulting in the discovery of the sands he had referred to, but the whole matter was under review and he believed that shortly some really up-to-date sand-preparation plant would be installed. All sorts of perrets had been tried, and at the moment his company was using perrets of stainless steel from this country.

The mills referred to in the Paper were just the ordinary ball mills, using porcelain balls, both for the wet grinding and dry grinding of enamel. They could not get pebbles which would enable them to produce enamel baths without black specks.

Frit Furnaces

MR. D. DIXON asked whether the frit furnaces were of the rotary or the stationary type; also whether silicon-carbide muffles were used wholly or whether firebrick muffles were used for part of the work. He had gathered that, so far, the continuous enamelling furnaces had not been used in Australia, and he asked if the author would confirm that.

MR. THOMAS replied that the frit furnaces used so far were of the stationary type and not rotary. There were some firebrick muffles in use as well as those of the carborundum type. His company had not used the continuous muffle in Australia, and during the last slump they were glad that they were not using it, because the output of any one product was not sufficient to warrant its use.

Types of Fuel Used

MR. J. GREEN said he had hoped the author would have discussed the use of different types of fuel for furnaces in Australia, and he asked for information as to the relative efficiencies and costs of using coal, oil, gas and electricity respectively in the furnaces. He also asked whether the silicon-carbide refractories used in Australia were imported from this country or from America. Bearing in mind the author's statement that cryolite was not found at all in Australia, he asked whether tin oxide only was used for securing opacity in glazes or whether cryolite was imported.

MR. THOMAS, replying to the question concerning fuels for furnaces, said that the coal available at Newcastle was of rather a soft nature, and the coal firing of muffles which was adopted originally was soon superseded by coke firing. Later, in the interests of cleanliness, coke firing was discontinued, and oil fuel was used. An electric muffle used at the Melbourne works had proved very successful, and the overall cost, taking into account all the advantages of using electricity, was not very much greater than that of the oil-fired muffle. The electric muffle was not, however, used for producing baths. Cryolite had to be imported.

MR. J. H. KING asked what was the sulphur content of the coke used in the muffles. He had noted that the sulphur content of the Australian cast iron for enamelling was 0.05 per cent.

MR. THOMAS replied that he had not at the moment the figures for the sulphur content of the coke used.

Skill Allowance

A MEMBER, referring to the wages paid in the foundries in Australia, said he gathered that each State fixed a basic rate (it was £3 18s. per week in New South Wales), and in addition there was an allowance for skill. He asked whether the latter allowance varied with the trade which a man followed, or whether it varied for each individual man according to his skill?

MR. THOMAS replied that the skill allowance varied in both respects; it varied according to the section in which the man worked and also with the length of time during which he had been engaged on his particular work, *i.e.*, it varied in accordance with a man's experience. Replying to another question as to whether there was any piecework in Australia, Mr. Thomas replied that there was. He had mentioned it in the Paper in regard to the production of baths; the piecerate could be applied if it were so fixed that a reasonably efficient man could earn 10 per cent. more when on piecework than when on timework.

MR. DIXON asked whether the dry process of bath enamelling was regarded as hazardous because of the fear of silicosis developing among the workers, or for any other reason.

MR. THOMAS said he had been rather hesitant about using the word "hazardous" in referring to the process in the Paper. Perhaps the idea that the process was hazardous had arisen as the result of experience with the lead enamels which were used in earlier days; or it might have been due to the fear of silicosis. But the trade was considered a semi-dangerous trade in Australia. His own company had not used lead enamels for a considerable time, but until quite recently some firms had used lead enamels for baths, and there had been a certain amount of trouble from lead poisoning. Nowadays, the use of lead and of arsenic had been banned completely.

Quality Comparison

A SPEAKER, commenting on the author's reference to the absence of black specks from Australian white enamelled goods, asked for a comparison of the qualities of Australian and English enamels in other respects.

MR. THOMAS said he really believed that in Australia his company turned out as good a quality of enamel as was produced in this country. The two countries worked on slightly different lines. The Australians had received as much advice from this country as they could have. Enamellers from this country went to Australia to put down the plant, and that was why, both in the foundry and in the enamelling shops, the Australians had followed British practice to a great extent; skilled men from Great Britain had been sent to Australia to teach the people there how to do the job. In regard to cleanliness, the Australians could show the enamellers of this country some points.

MR. E. H. BROWN asked what was the difference between the rate of wages paid to a fitter and the rates paid to workers in the patternshop and the foundry. Commenting upon the author's reference to the casting of six sinks in one box, he said it occurred to him that that box must be of considerable size. Finally, he asked for information as to the ranges of pig-iron normally available in Australia.

MR. THOMAS said he had not at the moment details of the rates of wages paid to various types of workers, for purposes of comparison, but such information was available. Actually, six sinks were cast in one box, and he drew attention to a photograph of the boxes, exhibited at the meeting. Pig-irons used in Australia were obtained from two or three sources. The analysis given in the Paper was that of the pig-iron which was found to be most suitable for enamelling, but he had not the analyses of the pig-irons from other sources.

Bad Sand and Good Finish

MR. G. C. PIERCE (Past-President of the London Branch, I.B.F.) said he would be particularly interested to know the kind of finish that was obtained on the castings produced in the wonderful sand mentioned in the Paper, which sand contained "knobs of quartz," and he asked what was the difference in finish as between the Australian and the British castings. Knowing the kind of finish that the English enamellers demanded, he wondered how nearly the finish of the Australian castings approached that, bearing in mind the sand which the Australians were using.

MR. THOMAS said that when he was in Australia a couple of years ago the finish of the castings was such that they would not have suited an English enameller, but more recently, since the new sands had been discovered, and since strict sand control had been instituted, the finish of the castings had become quite comparable with the best type of finish in this country. Of course, the castings had not the beautiful skin which was noted on the castings at the Nestor Martin foundry in Brussels when

* FOUNDRY TRADE JOURNAL, February 3, 1938, pp. 121-6.

the British foundrymen and vitreous enamellers had visited it. The sands which had been referred to as having "lumps of rock" in them, such as had had to be dealt with at Melbourne, were all screened, de-silted, and so on, before they could be used. The major difficulty in regard to sand and some other materials in Australia was that of the cost of transport. In Victoria the sands were probably available, but in cases where sand had to be transported over distances of 300 or 400 miles, the cost was serious. That difficulty applied also to a number of minerals; the minerals existed there, but they might have to be transported over long distances by camels, which latter were used extensively in the Australian desert. Large loads of mica were transported in that way. In view of the inaccessibility of some deposits it was not worth while working them.

Bubbling and Phosphorus Content

The CHAIRMAN (Dr. A. B. Everest) spoke of the excellence of the Paper and complimented the author upon his work in collecting the historical data. He said that on a recent visit to the United States he had noticed the use of permanent mould castings for enamel work to a certain extent, even for products as large as lavatory basins, etc. It seemed to him that for large production work there were obvious advantages in that type of moulding, and he asked whether it had been developed also in Australia.

Referring to the occurrence of bubbles in enamel, which it had been suggested was due to the interaction of the enamel with the constituents of the iron to which it was applied, he pointed out that the phosphorus content of Australian cast iron was only about half that of the British cast iron, and he asked whether the lower phosphorus content resulted in a closer-grained iron and in less bubbling of the enamel than was usual in this country.

MR. THOMAS replied that so far as he was aware, permanent moulds had not been used in Australia to produce castings for enamel work. Trouble with bubbling occurred in Australian enamelled ware just as it did in the British. He believed that the low-phosphorus content of the iron used in Australia was more a disadvantage than an advantage, and he personally would prefer that phosphorus content should be increased a little. Bubbling had occurred from time to time particularly in the bath castings, and they had rather concluded that, generally speaking, it occurred in places where the sand had not been sufficiently dried out and where the metal received a chill as it was poured. It was well known that a chill would cause the formation of bubbles. On the other hand, if such a casting were annealed afterwards, it would give quite satisfactory results. If a low-phosphorus content of the iron would help to ensure freedom from bubbling, one would expect that freedom throughout the whole of a bath casting, but it was not achieved throughout the whole casting.

Vote of Thanks

MR. C. P. STONE proposed a hearty vote of thanks to Mr. Thomas for his Paper. It was rather refreshing, he said, to hear that in Australia particular care was paid to the preparation of moulding sand; he personally considered that that represented half the battle. In years past, when he was associated with bath enamelling, he had never known a chill to cause "bubbling" of the enamel; but troubles could arise where a mould had not been properly dried out. It seemed therefore that the author had found the direct opposite to be the case in connection with baths as compared with the ordinary wet process enamelling, and where chilled castings presented boiling and blisters.

With regard to grit size of the sand tested, he suggested there must be a mistake in the author's figures, which indicated a residue of 50.5 per cent. on a 60-mesh sieve and 49.1 per cent. on a 90-mesh sieve.

It was true that the standard of the white enamel ware in Australia seemed higher than that produced in this country, and, indeed, it had to be, because of the predominance of the ultra-violet rays in the sunlight in Australia, which showed up defects at once; any defect in the surface of the enamel, viewed in such light, would simply glare at the observer, and an enamelled bath which looked quite good in this country would be rejected in Australia.

The Australian enamellers were advancing with the times, but he was rather surprised that the cost of operating electric muffles was more or less comparable with that of operating oil-fired muffles. It was well known that electricity produced a better result in a muffle than any other kind of heating medium, but the cost per hour of running an electric muffle in England was certainly very heavy. In this country the costs might be regarded as being in the ratio of 1s. for coal, 2s. 9d. to 3s. for oil, and 5s. for electric power. Often it was decided to use the cheapest fuel. He would always prefer the electric muffle, for there was no doubt that it was a really good job.

It seemed from the Paper that an air pressure of 100 lbs. per sq. in. was used for blasting, and probably that was the reason why the low-grade castings were cleaned quite well in Australia. There were not many in this country using an air pressure of 100 lbs. per sq. in. for blasting.

MR. F. HUDSON, who seconded the vote of thanks, said it was quite obvious, from the Paper and from the photographs which had been shown, that the equipment in the Australian works with which Mr. Thomas was associated was definitely modern. He agreed with Mr. Faulkner that a great deal could be learned from a country which had not to live down traditions such as applied in this country.

Foundrymen would have noticed that Mr. Thomas was making good-quality hot iron and yet was using a coke which probably no foundryman in this country would look at, for it contained about 15 per cent. of ash. He did not think Mr. Thomas had told the whole story. Perhaps the pig-irons that were being used were machine cast, in which case, of course, the little extra ash in the coke would be counter-balanced by the lesser amount of sand on the pigs. He asked if that were, in fact, the case.

Foundrymen in this country, particularly those who were making baths, would appreciate greater details of the sand used in Australia. He would like to know the complete ingredients of the mixture, exactly how much coal-dust was used, and what treatment was given to the moulds after they were made, whether they were sleeked or rubbed down with plumbago, or skin dried. Many firms in this country had tried to make baths by means of the sandslinger, using synthetic sands, but very few had made a success of it; he personally knew of only one firm out of the many that were making baths in this country who were able to make them by means of the sandslinger successfully.

Author's Reply

MR. THOMAS, responding, assured the meeting that the preparation of the Paper had been a source of great pleasure. Replying to Mr. Stone, he said that the air pressure of 100 lbs. per sq. in., mentioned with regard to blasting, was the storage pressure in the reservoir; actually the pressure was broken down to 60 lbs. per sq. in. for cleaning purposes. He had not the information required by Mr. Hudson at the moment concerning sand used and the treatment of the moulds, but he would be glad to obtain more information about that from Australia and communicate it.

When the sandslinger was introduced in 1924, admittedly they could make nothing of it, but inasmuch as several people were using it for the making of baths in the United States, his company had sent their foundry foreman to the States to obtain information. He was told to familiarise himself with the operation of the machine; he spent about four months in the United States, and since his return the sandslinger had been a wonderful success in Australia. Having regard to the high rates of wages paid there, to the high temperature of the summer months and the hard work entailed in ramming by hand, the sandslinger had been an absolute boon both to the employers and the employed. Its use resulted in saving wages and in saving the men a back-breaking job.

Alloy Irons for Clutch Housings

Lecturing before the Institution of Mechanical Engineers on the subject of the development of single-bucket excavators, MR. W. SAVAGE referred briefly to the construction of excavator clutches. Pointing out that the choice of the metal on which the friction lining of the clutch worked was very important, he proceeded to make the following observations on the materials used for the purpose:—

Cast steel, while being excellent from a structural point of view, scores badly. Cast iron is rather weak structurally, but works well with any form of lining. Research and field experience have proved that special iron alloys are the best materials for clutch housings, both from a structural and frictional point of view, and to-day they are widely used. The following is the specification of the nickel iron for clutch housings: total carbon, 3.3 per cent. maximum; silicon, 1.5 to 1.7 per cent.; manganese, 0.6 to 1.0 per cent.; sulphur, 0.12 per cent. maximum; phosphorus, 0.25 per cent. maximum; nickel, 1.0 per cent., and chromium, 0.25 per cent. All parts cast in this alloy are given the following annealing process: the parts are put into cold furnaces and heated to a temperature of 500 to 550 deg. C. and soaked at this temperature for a period of one hour; after this soaking, the parts are allowed to cool slowly in the furnaces.

"Semi-steel" castings are sometimes used, but from the point of view of friction are not so satisfactory. They contain 0.300 per cent. of phosphorus, not less than 0.75 per cent. manganese, not over 0.10 per cent. sulphur, 1.50 per cent. of silicon, and not less than 20 per cent. steel scrap. This material has a tensile strength of 13.4 to 15.6 tons per sq. in.

Catalogues Received

Eyesight Efficiency. An apparatus and a system are described in some publicity matter received from Stereosette, Limited, of 48, Gresham Street, London, E.C., which permit an unskilled member of a works welfare department to test the eyesight of the operatives. No claim is made that such an examination replaces a proper test by specialists, but, conversely, indicates whether such an examination is desirable. As defective eyesight is not realised by many so afflicted, it may be the basic cause of personal or machinery accident, or at the best, defective work or reduced output. Such tests should certainly be worth while in very many of the larger industrial establishments.

Non-Destructive Testing Equipment. The firm Bruno Suschyzki, of 25, Bitterstrasse, Dahlem, Berlin, has sent us a very interesting brochure dealing with the non-destructive testing of ferrous materials on the magnetic powder principle by means of the Ferroskop-Ferroflux method. Stationary and portable apparatus is described and illustrated, the latter displaying a high measure of ingenuity in construction, without resorting to the complex.

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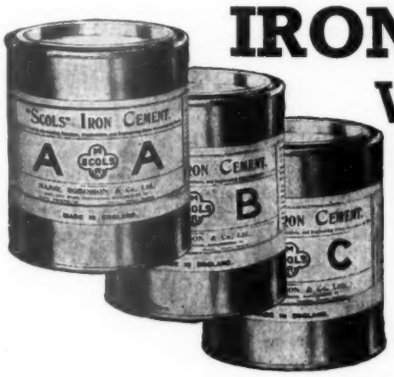

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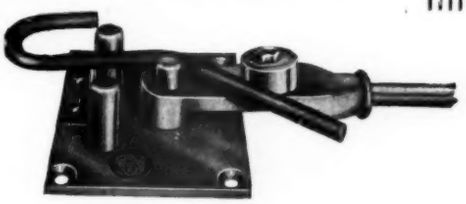

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The Week's News in Brief

Trade Talk

SKYLUX, LIMITED, tube and rod bending machinery manufacturers, have changed their address to Brunel Road, Acton, London, N.W.3.

GLENFIELD & KENNEDY, LIMITED, of Kilmarnock, are to supply a 35-ft. span sluice gate to be erected at Tewkesbury for the Severn Catchment Board.

THE CASTLE BROMWICH SECTION of the British Industries Fair, 1938, was attended by a total of 156,443 visitors. This is an increase of 3,794 on last year.

MR. G. R. SHARPLY, managing director of Ruston & Hornsby, Limited, of Lincoln and Grantham, has completed 50 years' service with the firm. He has received a presentation of a watercolour view of Lincoln.

CAPT. GRAHAM DONALD, of Craig & Donald, Limited, machine-tool makers and ironfounders, of Johnstone, took part in a broadcast last week on the Midland Regional programme from the Castle Bromwich Section of the British Industries Fair.

ACCORDING TO the annual accounts of the Port of Belfast, recently made available, the import of iron and steel castings has risen from 20,085 tons in 1926 to 23,166 tons in 1937. In general, the Port enjoyed a record year in 1937 for all types of business.

THE DIRECTORS OF VICKERS, LIMITED, recommend a dividend for the year 1937 at the rate of 10 per cent., less income tax at 5s. in the £, on the ordinary stock of the company. The transfer to reserves is £500,000 (£250,000 in 1936), and the carry forward £237,534 (£266,500 in 1936).

R. & W. HAWTHORN LESLIE & COMPANY, LIMITED, Hebburn-on-Tyne, have received an order for a cargo vessel of 4,000 tons for the Australian Steamship Proprietary, Limited, Sydney, Australia. The engines will be built by the North-Eastern Marine Engineering Company, Limited, Wallsend.

ALTERATIONS and additions to their existing premises are being carried out by A. P. Newall & Company, Limited, Woodside Engineering Works, Possilpark; Henry Wiggin & Company, Limited, Zenith Works, Thornliebank, Glasgow, and Abbotshaugh Engineering Company, Limited, Helen Street, Govan.

A SPECIAL EXHIBITION entitled "One Hundred Years of Transatlantic Steam Navigation" is being arranged by the Science Museum, South Kensington, London. It will commemorate the crossing of the Atlantic in April, 1838, by the pioneer transatlantic steamship, the little paddle steamer "Sirius." The exhibition will be open to the public from March 18 to the middle of September.

THIS YEAR will see the Diamond Jubilee of the Canadian National Exhibition at Toronto, and to mark the occasion, His Majesty's Government in the United Kingdom have accepted an invitation to organise a special exhibit. A large building has been placed at their disposal by the Exhibition authorities, and this, after adaptation and with the addition of a new facade, will become the United Kingdom Government Pavilion. The general theme chosen for the exhibits is the development of "communications and transport" and the part that they have played in improving the contact between different British countries throughout the world. The Travel and Industrial Association of Great Britain and Ireland will have a stand in the Government Pavilion. The Pavilion and the exhibits are being organised by the Department of Overseas Trade in London. It is understood that the arrangements for the British Manufacturers' Section are progressing very favourably.

Obituary

THE DEATH has occurred of Mr. Adam Louden, who retired two years ago from the service of A. Ballantine & Sons, Limited, New Grange Foundry, Bo'ness, where he was at that time the oldest employee. He began work in the foundry of White & Bradford, and later went to the Seaview Foundry of Morrison & Company. After the war he returned to the New Grange Foundry. He was 74 years of age.

Personal

MR. CHARLES DAY, chairman of Mirrlees, Bickerton & Day, Limited, has joined the board of Petters, Limited.

MR. WILLIAM MAWER, of Motherwell, has been elected President of the Executive of the Iron and Steel Trades Confederation.

MR. E. A. TIMSON, a director of Timsons, Limited, engineers and ironfounders, of Kettering, has been elected to the Kettering Urban Council.

MR. F. BIRCHALL, managing director of Peglers, Limited, brassfounders, Doncaster, has been elected chairman of the company in succession to the late Mr. Francis Pegler.

DR. ROBERT HUNTER has been appointed a director of the Clyde Alloy Steel Company, Limited. He has been in the service of the company for many years as metallurgist.

MR. I. H. BRIERLEY, managing director of Isaac Brierley & Company, Limited, brassfounders, of Royton, Lancs, celebrated his 70th birthday recently, and was made the recipient of an inscribed clock from the employees of the firm.

MR. ALEXANDER WILLIAMSON, general manager of the Steel, Peech & Tozer branch of the United Steel Companies, Limited, and an ex-Master Cutler of Sheffield, has been appointed managing director of William Beardmore & Company, Limited, of Parkhead, Glasgow.

MR. J. BOLTON has been appointed Assistant Secretary to the Institute of British Foundrymen, and commenced his duties in Manchester at the beginning of the present month. He was formerly on the staff of THE FOUNDRY TRADE JOURNAL as assistant to the Editor, and in this capacity made many contacts with the foundry industry. His metallurgical training was received at the Sir John Cass Technical Institute, London.

Contracts Open

Cape Town, April 8.—Cast-iron pipes, etc., for the Cape Town Electricity Supply Commission. The Department of Overseas Trade. (Reference T. 18404/38.)

Carlisle, March 14.—Steam pipe and fittings; lead and compo pipe; cast-iron goods; brass fittings; malleable iron fittings, for the Town Council. The Gas Engineer, Gasworks, Carlisle.

Chippenham, March 19.—Provision and laying of 270 yds. of 6-in. dia. and 950 yds. of 4-in. dia. coated cast-iron pipes, for the Town Council. Mr. C. R. Phillips, borough surveyor, High Street, Chippenham, Wilts. (Fee £1 1s., returnable.)

Darlington, March 15.—Iron and steel; cast-iron pipes; miscellaneous castings, etc., for the Town Council. The Borough Surveyor, Town Hall, Darlington.

Aberystwyth, March 15.—A.c. electricity meters, for the Town Council. May & Hawes, consulting engineers, 36, Victoria Street, Westminster, S.W.1.

Blackpool, March 14.—Supply and installation of raking screen, together with electric motor, starting gear, etc., for the Town Council. The Borough Engineer, Municipal Offices, Talbot Square, Blackpool. (Fee £1 1s., returnable.)

Blackpool, March 17.—Supply and installation of three vertical-spindle centrifugal pumps (two seawater pumps and one sludge pump) of 500 g.p.m. capacity each, with electric motors, starting gear, etc., for the Town Council. The Borough Engineer, Municipal Offices, Talbot Square, Blackpool. (Fee £1 1s., returnable.)

Cairo, April 2.—Electrical and pumping plant, travelling cranes, cables, etc., for the Ministry of Public Works. The Department of Overseas Trade. (Reference T.Y. 18398/38.)

Johannesburg, April 5.—Vertical spindle centrifugal pump direct-coupled to an electric motor, for the Rand Water Board. The Department of Overseas Trade. (Reference T.Y. 18,300/38.)

Johannesburg, May 2.—Portable steam roller, for the South African Railways and Harbours Administration. The Department of Overseas Trade. (Reference T. 18291/38.)

Dr. C. H. Desch to Receive Bessemer Gold Medal

The Council of the Iron and Steel Institute announce that they have awarded the Bessemer Gold Medal for 1938 to Dr. C. H. Desch, F.R.S., Superintendent of the Metallurgical Department of the National Physical Laboratory, Teddington. The presentation will be made at the annual general meeting of the Institute on May 4, 1938.

Dr. C. H. Desch has long been distinguished as a teacher of metallurgical chemistry. He was lecturer in this subject at the University of Glasgow and, subsequently, Professor of Metallurgy at the Royal Technical College, and later at the University of Sheffield, where he succeeded the late Professor Arnold. His text-book on "Metallography" has been for many years the classical publication on this subject in Great Britain. He is a leading authority on the chemistry of solids, upon which he gave a series of lectures recently at the University of Cornell. In 1932 he was appointed to succeed the late Dr. W. Rosenhain, F.R.S., as Superintendent of the Metallurgical Department at the National Physical Laboratory. Since that time he has been in charge of researches which have for their object the production of metals of the highest degree of purity obtainable, for the purposes of research—in particular the metals of the iron group. Under his leadership, methods have also been worked out for estimating, in a satisfactory manner, the oxygen content of steels. He is a Past-President of the Faraday Society and President of the Institute of Metals.

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Arthur Hughes & Sons (Ironfounders), Limited, Old Road, Failsworth, Lancs.—Capital, £1,000. Directors: A. Hughes and A. H. Hughes.

A. C. Wickman, Limited.—Capital, £100. Machine-tool makers, ironfounders, etc. Subscriber: G. Conrad, 103, Phyllis Avenue, New Malden.

Newtons (Ironfounders), Limited, Albion Foundry, Vickers Street, Miles Platting, Manchester.—Capital, £10,000. Directors: W. Newton, F. Newton and R. B. Newton.

Forthcoming Events

MARCH 14.

Institute of Metals (Scottish Section):—"What Conventional Mechanical Properties Tell Us about Materials," Paper by G. W. Austin, at 39, Elmbank Crescent, at 7.30 p.m.

MARCH 15.

Institute of Metals (North-East Coast Section):—"Magnesium Alloy Castings," Paper by O. Kennedy, at Armstrong College, Newcastle-upon-Tyne, at 7.30 p.m.

MARCH 17.

Institution of Mechanical Engineers (Midland Branch):—"Metallurgical Inspection of Steel," Paper by J. S. G. Primrose, at James Watt Memorial Institute, Birmingham, at 6.30 p.m.

MARCH 18.

Keighley Association of Engineers:—Annual dinner, at Victoria Hotel, Keighley, at 7 p.m.

Institute of British Foundrymen

MARCH 14.

Lincolnshire Section:—"Foundry Sands," Paper by B. Hird, at Lincoln Technical College, at 6.45 p.m.

MARCH 15.

Sheffield Branch:—Joint meeting with Iron and Steel Institute and Sheffield Metallurgical Association. Discussion of 1st Report of Ingot Moulds Sub-committee of Iron and Steel Institute, at 196, West Street, Sheffield, at 7.30 p.m.

MARCH 17.

East Anglian Section:—Annual meeting and Short Paper competition, at Central Library, Ipswich, at 7.30 p.m.

MARCH 18.

Middlesbrough Branch:—"Corrosion-Resisting Cast Iron—Its Production and Use," Paper by F. Hudson, at Cleveland Scientific and Technical Institute, Corporation Road, Middlesbrough.

MARCH 19.

Wales and Monmouth Branch:—Annual meeting, at University College, Cardiff, at 6.30 p.m.

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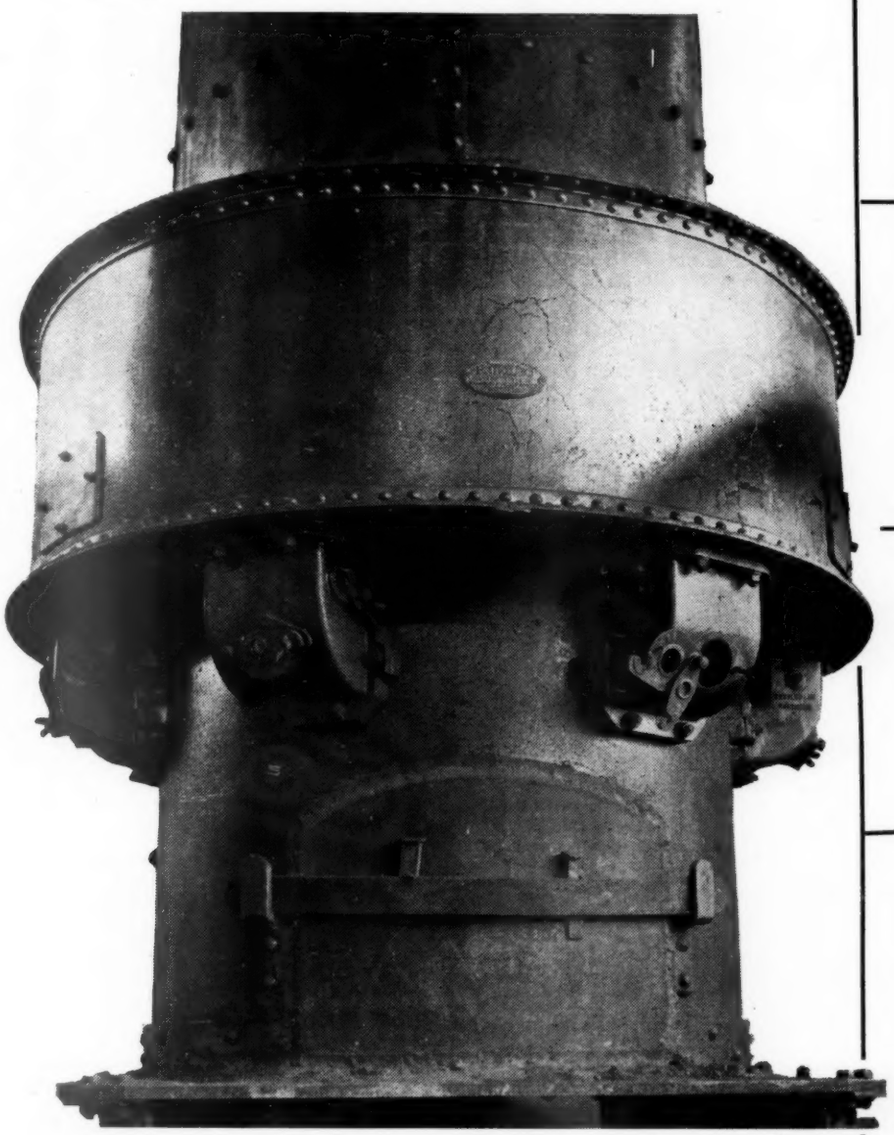

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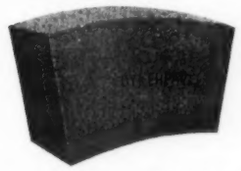

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SWANSEA OFFICE: Metropole Chambers, Wind Street. Telephone: 3680. Telegrams: "Genefax, Swansea." (Mr. D. F. Hood-Williams).

MANCHESTER OFFICE: 9, Albert Square. Telephone: Blackfriars 6130 Telegrams: "Genefax, Manchester." (Mr. S. G. Throssell).

MIDDLESBROUGH OFFICE: Halifax Bldgs., Exchange Place, Telephone: Middlesbrough 3313. Telegrams: "Genefax, Middlesbrough." (Mr. J. A. Williams).

CARDIFF OFFICE: 17, Windsor Place, Telephone: 5796. Telegrams: "Genefax, Cardiff." (Mr. F. E. Rutter).

Raw Material Markets

While it must be admitted that there are no signs at the moment of activity in the iron and steel consuming industries returning to former levels, it is confidently anticipated that trade will be better in the spring. New business is still quiet and some producers are finding it difficult to get users to take up their full contract quantities.

Pig-Iron

MIDDLESBROUGH.—Home and export inquiries remain on the slow side and stocks at the producers' works are accumulating. Imports have continued to arrive in heavy tonnages, but application has been made to the Import Duties Advisory Committee for a restoration of the tariff on foreign pig-iron. If this is agreed to, the demand for home-produced iron should become stronger, though the rebate scheme itself acts as an effective brake on imports. For delivery in the Middlesbrough and Falkirk districts, No. 3 Cleveland G.M.B. iron is quoted at 109s. per ton, less 5s. rebate. Good deliveries of hematite are being made under existing contracts, but, as most consumers have contracted for their requirements at least for the first half of the year, there is little new business offering. Only a small export inquiry is circulating. East Coast mixed numbers are quoted at 132s. 6d. on the North-East Coast, 138s. in Sheffield, and 143s. 6d. in the Midlands, all less 5s. rebate.

LANCASHIRE.—The Exchange meetings are still poorly attended, there being no pressure to enter into new contracts. Deliveries are more than adequate to enable consumers to operate at the required level in most cases, and stocks are now quite substantial. Light-castings and textile-machinery makers continue to be unsatisfactorily employed, but most other consumers are working quite well. For delivery in the Manchester price zone, Derbyshire and Staffordshire No. 3 is quoted at 114s. per ton, with Northamptonshire at 112s. 6d. and Derbyshire forge iron at from 111s. to 113s., according to the class of consumer. West Coast hematite is quoted at 141s., with East Coast iron at 140s. 6d., delivered in Manchester and district, and subject to 5s. per ton rebate. There is only a small tonnage of Scottish No. 3 iron offered at about 141s. per ton.

MIDLANDS.—With most consumers of pig-iron still unsatisfactorily placed for work, the furnaces are concerned almost solely with the despatch of contract deliveries. Producers are in the position to send off heavy tonnages, and stocks are mounting week by week. Consumers, also, have large stocks, and new business is restricted to single truck loads. For delivery to Birmingham and Black Country stations, Derbyshire No. 3 is quoted at 111s., with Northamptonshire No. 3 at 108s. 6d., less 5s. per ton rebate. The demand for low-phosphorus pig-iron is still quite heavy. Prices vary from £6 5s. up to £7 7s. 6d. for delivery in the Midlands. Hematite makers have recently stated that there will be no change in prices before December 31. At present, most users have covered their needs up to the end of June only, but this assurance with regard to prices may produce further inquiries. East Coast No. 3 is quoted at 143s. 6d., with West Coast mixed numbers at 144s. 6d., less 5s. rebate.

SCOTLAND.—The steelworks in this area remain very active, and are taking up heavy tonnages of hematite and basic, but foundry iron is now being stocked; in fact, most consumers do not require the tonnage they had previously booked. No. 1 foundry iron is quoted at £6 0s. 6d., with No. 3 2s. 6d. per ton less, delivered f.o.t. furnaces. For export, No. 3 foundry is at £6 3s. per ton, f.o.b. Glasgow. Hematite mixed numbers are at £6 13s., Scottish basic at £5 7s. 6d., and English and Indian basic at £5, all less 5s. rebate and delivered f.o.t. steelworks.

Coke

In view of the less active conditions at the ironworks, the demand for coke has declined of late, although deliveries are still being called for. Prices of foundry coke for delivery in Birmingham and district are maintained at 55s. 9d., minimum, for best Durham foundry coke, and 55s. to 62s. 6d. for Welsh coke. There has been little business transacted for deliveries after the end of June, as consumers regard current prices as being too high and are hoping for a reduction.

Steel

Quiet conditions rule in the steel market, although there is little indication of a decline in the tonnage passing into consumption. Most consumers have purchased their requirements for as far forward as they care to commit themselves, and, as a consequence, it is not expected that great activity will rule in the market for the next month or two. In the semi-finished steel department, full supplies are now available for all classes of consumers, and this has enabled the finishing works to overtake arrears of orders. The demand for finished steel is steady, but, with all the heavy steel works operating at full capacity, contracts are being worked off more quickly than new business is coming forward; but it is still difficult to place orders for near delivery for some descriptions of steel. While export business remains quiet, Continental prices have shown a firmer tendency as a result of the recent meetings of the British, Cartel and American steelmakers.

Scrap

Steelworks' scrap remains the most active, but in some areas there has been a decline in the demand for these descriptions. Supplies are fairly plentiful, both in iron and steel, and are in excess of the demand. Generally, steelmakers have covered their requirements, and there is unlikely to be much new business for several months.

Metals

The Malayan Government has announced that it is considering a scheme whereby miners may produce an extra percentage during the second quarter of the year. Despite the serious labour situation, the proposals came as a surprise to the tin industry in Malaya.

Copper.—Following an improved demand last week, this market has again become very quiet. Japanese inquiries are slight, but Russia continues to be in the market for heavy tonnages. In the United States, also, the market has a dull tone and sales are at a low level.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £40 2s. 6d. to £40 5s.; Friday, £40 2s. 6d. to £40 3s. 9d.; Monday, £40 2s. 6d. to £40 5s.; Tuesday, £39 17s. 6d. to £40; Wednesday, £39 17s. 6d. to £40.

Three Months.—Thursday, £40 7s. 6d. to £40 8s. 9d.; Friday, £40 8s. 9d. to £40 10s.; Monday, £40 7s. 6d. to £40 8s. 9d.; Tuesday, £40 2s. 6d. to £40 3s. 9d.; Wednesday, £40 2s. 6d. to £40 3s. 9d.

Tin.—According to the monthly tin statistics compiled by Mr. W. H. Gartsen (Henry Rogers, Sons & Company), the total visible supply on February 28 was 16,402 tons, as compared with 16,831 tons on January 31. The carry-over on the same date in the Straits Settlements was 4,650 (6,133) tons, and at the Arnhem (Holland) smelter 2,256 (2,003) tons. It had been expected that the total supplies in sight would have been unchanged on the month.

It has been officially stated in Singapore that, in view of the effect of the reduced tin quota for April and June on the labour situation in the tin-mining industry, the Government is considering a scheme, liable to adjustment according to the total stock in the mines on March 31 and to changes in the international rate of release, whereby miners may produce an extra percentage during April and June, to be held in bond at smelters' works at Singapore and Penang. Such excess of production is to be deducted from the quotas in the succeeding quarters, with complete liquidation within one year or earlier should the domestic rate of release at any time exceed 50 per cent. It is suggested that the quantity of tin deposited in bond under the scheme should not exceed 2,900 tons, which is equivalent to a rate of 12 per cent. of the domestic assessment.

This announcement was well received by local miners, who regard it as a direct warning to the International Tin Committee that Malaya will be unable to make further sacrifices. It is understood that the Government is prepared to grant to producers $50 per picul (133 lbs.)—about £100 a ton—the advance to bear interest probably at 4 per cent. and to be secured against the metal and recoverable from the proceeds of the sale. The scheme is designed to encourage the smaller mines to continue working rather than close down. It is officially denied that the plan is the first step towards the establishment of a new buffer pool. Netherlands East Indies producers are reported to be "not perturbed" by the Malayan plan.

Mr. Choo Kiapeng, a leading Chinese tin mine owner, presiding at the annual meeting of the Selangor Miners' Association at Kuala Lumpur recently, criticised severe and sudden quota cuts, declaring that they endangered the peace and stability of the country and were detrimental to the welfare of labourers and miners. He was in favour of tin restriction so far as it was managed in a sane manner, but the price factor should not be the principal consideration.

Official quotations were as follow :—

Cash.—Thursday, £185 5s. to £185 10s.; Friday, £185 7s. 6d. to £185 10s.; Monday, £185 7s. 6d. to £185 10s.; Tuesday, £185 10s. to £185 12s. 6d.; Wednesday, £185 17s. 6d. to £186.

Three Months.—Thursday, £184 15s. to £185; Friday, £184 17s. 6d. to £185 2s. 6d.; Monday, £185 to £185 10s.; Tuesday, £185 5s. to £185 10s.; Wednesday, £185 17s. 6d. to £186.

Spelter.—The weekly market report issued by Brandeis, Goldschmidt & Company, Limited, states that consumers are showing very little interest in the metal at the present time, and do not seem to be at all anxious to cover their forward requirements. While the American market has no direct influence on the world price, there is no doubt that disappointment is being felt in that country with the volume of fresh sales at the present comparatively low level of 4.75 cents, St. Louis. This, in turn, has had a sentimental influence in the rest of the world, where production is certainly ample for the present requirements of the trade. On the other hand, the price of the metal is not high, and the demand from certain branches of the consuming industries is likely to remain good.

Daily market prices :—

Ordinary.—Thursday, £13 17s. 6d.; Friday, £13 17s. 6d.; Monday, £14 1s. 3d.; Tuesday, £14 1s. 3d.; Wednesday, £14 3s. 9d.

Lead.—Apart from some substantial buying from the Soviet Union, this market has remained very quiet. Consumption is reported to be well maintained, and heavier business is expected to materialise within a short period.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £15 6s. 3d.; Friday, £15 5s.; Monday, £15 5s.; Tuesday, £15 6s. 3d.; Wednesday, £15 10s.

Scrap.—There is still a very quiet tone in this market, and business involves only small parcels. Price movements have continued to be in a downward direction.

Approximate selling prices for old metal :—New aluminium cuttings, £80; rolled, £63; cast, £38; foil, £88. Copper, £38 to £40; braziery, £34. Brass (clean), £24 to £26. Zinc, £7 10s. Lead, £13. Gunmetal, £38 to £40.

Company Reports

Colvilles, Limited.—Final dividend on the ordinary stock of 5 per cent., making 8 per cent. for 1937.

Bairds & Dalmellington, Limited.—Final ordinary dividend of 12 per cent., making 16 per cent. for 1937.

Swan, Hunter & Wigham Richardson, Limited.—Final dividend of 7 per cent., making 9 per cent. for the year.

Ley's Foundries & Engineering, Limited.—Half-yearly dividend on the 5 per cent. cumulative preference shares.

Federated Foundries, Limited.—Profit for year to December 31 last, together with balance brought forward from 1936, £57,000; dividend for the half-year to December 31, 1937, on the 5 per cent. cumulative preference shares; no ordinary dividend.

C. Akrill & Company, Limited.—Profit for 1937, £15,165; brought in, £19,573; dividend of 2s. per share, free of tax, £4,375; bonus of 1s. per share, free of tax, £2,187; to employees' benevolent and superannuation fund, £1,293; to special development and extensions reserve, £3,000; to revenue reserve fund, £3,125; carried forward, after preference dividend, £20,532. Meeting, March 14.

Are you ready?

Randupson will reduce by 40% your Dry Sand Casting Costs for Moulds & Cores—Iron, Steel & Non-Ferrous.

Hinckleys Ltd.

RAW MATERIALS—PRICE LIST

(Wednesday, March 9, 1938)

COPPER

	£	s.	d.
Standard cash	39	17	6
Three months	40	2	6
Electrolytic	43	12	6
Tough	42	15	0
Best selected	43	5	0
Sheets	75	0	0
India	56	2	6
Wire bars	44	10	0
Ingot bars	44	15	0
H.C. Wire rods	48	0	0
Off. av. cash, Feb.	39	12	10½
Do., 3 mths., Feb.	39	17	1⅛
Do., Sttlmnt., Feb.	39	13	0
Do., Electro, Feb.	43	19	2½
Do., B.S., Feb.	43	10	7½
Do., Wire bars, Feb.	44	7	1½
Solid drawn tubes			12½d.
Brazed tubes			12½d.
Wire			8½d.

BRASS

Solid drawn tubes	11½d.
Brazed tubes	13½d.
Rods, drawn	9d.
Rods, extd. or rlld.	6½d.
Sheets to 10 w.g.	8⅜d.
Wire	8½d.
Rolled metal	7⅞d.
Yellow metal rods	6¼d.

TIN

	£	s.	d.
Standard cash	185	17	6
Three months	185	17	6
English	185	17	6
Bars	187	10	0
Straits	187	0	0
Eastern	187	5	0
Banca (nom.)			—
Off. av. cash, Feb.	183	5	3¾
Do., 3 mths., Feb.	183	2	9¾
Do., Sttlmt., Feb.	183	4	6

SPELTER

	£	s.	d.
Ordinary	14	3	9
Remelted	11	10	0
Hard	11	5	0
Electro, 99·9	18	2	6
English	15	5	0
India	13	10	0
Zinc dust	20	10	0
Zinc ashes	5	0	0
Off. aver., Feb.	14	9	11⅝
Aver., spot, Feb.	14	8	1⅞

LEAD

	£	s.	d.
Soft foreign, ppt.	15	10	0
Empire (nom.)	16	2	6
English	17	10	0
Sheets, home	23	0	0
Do. export	19	5	0
Pipes, home	22	10	0
Do. export	19	17	6
Tea lead	31	5	0
Off. aver., Feb.	15	9	3 3/16
Aver., spot, Feb.	15	8	0⅞

ALUMINIUM

Ingots	£100 to £105
Wire	1/3 to 1/4 lb.
Sheet and foil	1/2 to 1/4 lb.

ZINC SHEETS, &c.

Zinc sheets, English	28	15 0 to 29	5 0
Do., V.M. ex-whse.	28	15 0 to 29	5 0
Rods		20	10 0

ANTIMONY

	£	s.	d. to £	s.	d.
English	81	0	0 to 82	0	0
Chinese, ex-whse.			67	0	0
Crude, c.i.f.			40	0	0

QUICKSILVER

Quicksilver	12	7	6

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—			
25%	12	10	0
45/50%	12	0	0
75%	17	0	0
Ferro-vanadium—			
35/50%	14/- lb. Va.		
Ferro-molybdenum—			
70/75% carbon-free	4/9 lb. Mo.		
Ferro-titanium—			
20/25% carbon-free	9d. lb.		
Ferro-phosphorus, 20/25%	£21 to £22		
Ferro-tungsten—			
80/85%	6/- lb. (nom.)		
Tungsten metal powder—			
98/99%	6/1½ lb. (nom.)		
Ferro-chrome—			
2/4% car.	34	15	0
4/6% car.	24	5	0
6/8% car.	24	0	0
8/10% car.	24	0	0
Ferro-chrome—			
Max. 2% car.	36	0	0
Max. 1% car.	38	5	0
Max. 0·5% car.	41	0	0
70% carbon-free	10d. lb.		
Nickel—99·5/100%	£180 to £185		
"F" nickel shot	£165	0	0
Ferro-cobalt, 98/99%	8/6 to 8/9 lb.		
Metallic chromium—			
96/98%	2/5 lb.		
Ferro-manganese—			
76/80% loose	£18 15 0 to 19	5	0
76/80% packed	£19 15 0 to 20	5	0
76/80% export	£22	0	0
Metallic manganese—			
94/96% carbon-free	1/3 lb.		

Per ton unless otherwise stated, basis 2-ton lots.

SCRAP

South Wales (West)—	£	s.	d.	£	s.	d.
Heavy steel, best	3	8	9 to 3	11	3	
Mixed iron and steel	3	6	9 to 3	9	3	
Heavy cast iron	3	8	9 to 3	11	3	
Good machinery				3	15	0
Cleveland—						
Heavy steel, best	3	7	0 to 3	9	6	
Steel turnings	2	13	0 to 2	15	6	
Heavy cast iron				4	0	0
Heavy machinery				4	5	0
Midlands—						
Short heavy steel	3	15	0 to 3	17	6	
Light cast-iron scrap				3	2	6
Heavy wrought iron	4	0	0 to 4	5	0	
Steel turnings	2	6	3 to 2	8	9	
Scotland—						
Heavy steel, best	3	5	0 to 3	7	6	
Ordinary cast iron	4	0	0 to 4	2	6	
Cast-iron borings	2	0	6 to 2	3	0	
Wrot-iron piling	4	5	0 to 4	7	6	
Heavy machinery				4	10	0

London—Merchants' buying prices, delivered yard.

Copper (clean)	32	0	0
Brass	22	10	0
Lead (less usual draft)	13	0	0
Tea lead	9	10	0
Zinc	7	0	0
New aluminium cuttings	70	0	0
Braziery copper	32	0	0
Gunmetal	32	0	0
Hollow pewter	130	0	0
Shaped black pewter	90	0	0

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	3s. 6d.
Finished bars, 18% tungsten	4s. 6d.

Per lb. d/d buyers' works.

PIG-IRON*

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	111/6
,, No. 3	109/-
,, No. 4	108/-
Forge No. 4	108/-
Hematite No. 1	133/-
Hematite M/Nos.	132/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	133/-
,, d/d Birm.	144/6
Malleable iron d/d Birm.	165/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	110/-
,, No. 3 fdry.	111/-
Northants forge	107/6
,, fdry. No. 3	108/6
,, fdry. No. 1	111/6
Derbyshire forge	110/-
,, fdry. No. 3	111/-
,, fdry. No. 1	114/-
Scotland—	
Foundry, No. 1, f.o.t.	120/6
,, No. 3, f.o.t.	118/-
Cleveland No. 3, Glasgow	112/-
,, ,, Falkirk	109/-
Scottish hem. M/Nos. d/d	133/-
Sheffield (d/d district)—	
Derby forge	107/6
,, fdry. No. 3	108/6
Lincs forge	107/6
,, fdry. No. 3	108/6
W.C. hematite	138/6
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	114/-
Staffs fdry. No. 3	114/-
Northants fdry. No. 3	112/6
Cleveland fdry. No. 3	114/-
Glengarnock, No. 3	141/-
Clyde, No. 3	141/-
Monkland, No. 3	141/-
Eglinton, No. 3	141/-
Gartsherrie, No. 3	141/-
Shotts, No. 3	141/-

(* Prices of hematite and basic pig-iron, and of foundry and forge iron with a phosphoric content of not less than 0·75 per cent., are subject to a rebate of 5s. per ton under certain conditions.)

FINISHED IRON AND STEEL

Usual district deliveries.

[A rebate of 15/- per ton for steel sections, plates and joists is obtainable in the home trade under certain conditions.]

Iron—	£	s.	d.	£	s.	d.
Bars (cr.)	13	5	0 to 13	15	0	
Nut and bolt iron	11	12	6 to 12	2	6	
Hoops				14	2	6
Marked bars (Staffs) f.o.t.				15	15	0
Gas strip				14	2	6
Bolts and nuts, ¾ in. × 4 in.			17 10	0	and up	
Steel—						
Plates, ship, etc.	11	8	0 to 11	10	6	
Boiler plts.	11	18	0 to 12	0	6	
Chequer plts.				13	0	6
Angles				11	0	6
Tees				12	0	6
Joists				11	0	6
Rounds and squares, 3 in. to 5½ in.				12	0	6
Rounds under 3 in. to ⅝ in. (untested)				11	9	0
Flats—8 in. wide and over				11	5	6
,, under 8 in. and over 5 in.				11	10	6
Rails, heavy				10	2	6
Fishplates				14	2	6
Hoops (Staffs)				12	4	0
Black sheets, 24g. (4-t. lots)				15	15	0
Galv. cor. shts. (,,)				18	10	0
Galv. flat shts. (,,)				19	0	0
Galv. fencing wire, 8g. plain				20	5	0
Billets, soft, 100-ton lots				7	17	6
Sheet bars				7	15	0
Tin bars				7	15	0

PHOSPHOR BRONZE

	Per lb. basis
Strip	10¾d.
Sheet to 10 w.g.	11¼d.
Wire	12⅞d.
Rods	13¼d.
Tubes	18½d.
Castings	15d.

Delivery 3 cwt. free.
10% phos. cop. £33 above B.S.
15% phos. cop. £38 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	8d. to 1/2
Rolled—	
To 9 in. wide	1/2 to 1/8
To 12 in. wide	1/2¼ to 1/8¼
To 15 in. wide	1/2¼ to 1/8½
To 18 in. wide	1/3 to 1/9
To 21 in. wide	1/3½ to 1/9½
To 25 in. wide	1/4 to 1/10
Ingots for spoons and forks	8d. to 1/4½
Ingots rolled to spoon size	11d. to 1/7½
Wire round—	
to 10g.	1/5½ to 2/0½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/4½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	25.84
No. 2 foundry, Valley	24.00
No. 2 foundry, Birm.	20.38
Basic, Valley	23.50
Malleable, Valley	24.00
Grey forge, Valley	23.50
Ferro-mang. 80%, seaboard	102.50
O.-h. rails, h'y, at mill	42.50
Billets	37.00
Sheet bars	37.00
Wire rods	47.00
	Cents.
Iron bars, Chicago	2.40
Steel bars	2.45
Tank plates	2.25
Beams, etc.	2.25
Skelp, grooved steel	2.10
Steel hoops	2.40
Sheets, black, No. 24	3.15
Sheets, galv., No. 24	3.80
Wire nails	2.75
Plain wire	2.90
Barbed wire, galv.	3.40
Tinplates, 100-lb. box	$5.35

COKE (at ovens)

Welsh foundry	42/6
,, furnace	37/6
Durham foundry	39/6
,, furnace	32/6
Scottish foundry	41/6
,, furnace	40/-

TINPLATES

f.o.b. British Channel ports.

I.C. cokes	20×14 per box		22/6
,,	28×20 ,,		45/-
,,	20×10 ,,		34/9
,,	18¾×14 ,,		24/9
C.W.	20×14 ,,	17/9 to	18/6
,,	28×20 ,,	35/6 to	37/-
,,	20×10 ,,	29/3 to	29/9
,,	18¾×14 ,,	20/9 to	21/3

SWEDISH CHARCOAL IRON & STEEL

	£	s.	d. to £	s.	d.
Pig-iron	12	0	0 to 13	0	0
Bars-hammered, basis	20	0	0 to 22	0	0
Bars and nail-rods, rolled, basis	19	0	0 to 20	0	0
Blooms	18	0	0 to 19	0	0
Keg steel	30	0	0 to 35	0	0
Faggot steel	20	0	0 to 25	0	0
Bars and rods dead soft st'l	19	0	0 to 20	0	0

All per English ton, f.o.b. Gothenburg
[Subject to an exchange basis of Kr 19.39 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

		£ s. d.	
Mar. 3 ..	40 2 6	dec.	2/6
,, 4 ..	40 2 6	No	change
,, 7 ..	40 2 6	,,	,,
,, 8 ..	39 17 6	dec.	5/-
,, 9 ..	39 17 6	No	change

Electrolytic Copper

		£ s. d.	
Mar. 3 ..	44 10 0	inc.	10/-
,, 4 ..	44 10 0	No	change
,, 7 ..	44 5 0	dec.	5/-
,, 8 ..	44 0 0	,,	5/-
,, 9 ..	43 12 6	,,	7/6

Standard Tin (cash)

		£ s. d.		
Mar. 3 ..	185 5 0	dec.	25/-
,, 4 ..	185 7 6	inc.	2/6
,, 7 ..	185 7 6	No	change
,, 8 ..	185 10 0	inc.	2/6
,, 9 ..	185 17 6	,,	7/6

Tin (English ingots)

		£ s. d.		
Mar. 3 ..	185 5 0	dec.	25/-
,, 4 ..	185 7 6	inc.	2/6
,, 7 ..	185 7 6	No	change
,, 8 ..	185 10 0	inc.	2/6
,, 9 ..	185 17 6	,,	7/6

Spelter (ordinary)

		£ s. d.		
Mar. 3 ..	13 17 6	dec.	10/-
,, 4 ..	13 17 6	No	change
,, 7 ..	14 1 3	inc.	3/9
,, 8 ..	14 1 3	No	change
,, 9 ..	14 3 9	inc.	2/6

Spelter (Electro, 99.9 per cent.)

		£ s. d.		
Mar. 3 ..	17 15 0	dec.	11/3
,, 4 ..	17 15 0	No	change
,, 7 ..	18 0 0	inc.	5/-
,, 8 ..	18 0 0	No	change
,, 9 ..	18 2 6	inc.	2/6

Lead (soft foreign, prompt)

		£ s. d.		
Mar. 3 ..	15 6 3	No	change
,, 4 ..	15 5 0	dec.	1/3
,, 7 ..	15 5 0	No	change
,, 8 ..	15 6 3	inc.	1/3
,, 9 ..	15 10 0	,,	3/9

Lead (English)

		£ s. d.		
Mar. 3 ..	17 10 0	No	change
,, 4 ..	17 10 0	,,	,,
,, 7 ..	17 5 0	dec.	5/-
,, 8 ..	17 5 0	No	change
,, 9 ..	17 10 0	inc.	5/-

AVERAGE MONTHLY PRICES OF DERBYSHIRE NO. 3 FOUNDRY AT MANCHESTER.

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1902	2 17 6	2 17 6	2 15 6	2 16 9	2 16 6	2 16 6	2 16 6	2 17 0	2 18 6	2 17 6	2 17 6	2 17 6	2 17 1½
1903	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6
1904	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6
1905	2 13 0	2 13 0	2 11 6	2 12 6	2 12 0	2 12 0	2 12 3	2 12 3	2 14 0	2 18 6	3 0 0	3 0 6	2 14 1
1906	3 2 0	3 5 0	3 3 0	3 0 6	2 17 0	2 18 6	2 18 0	2 16 6	2 19 0	3 0 6	3 1 6	3 7 0	3 0 8½
1907	3 7 0	3 7 0	3 5 0	3 2 0	3 4 0	3 8 0	3 6 0	3 5 0	3 4 0	3 2 6	3 1 0	2 18 6	3 4 2
1908	2 15 0	2 14 6	2 14 6	2 15 6	2 14 0	2 13 0	2 13 0	2 11 6	2 12 6	2 13 0	2 12	2 12 6	2 13 5½
1909	2 13 0	2 12 6	2 11 6	2 12 0	2 12 6	2 12 6	2 12 0	2 12 6	2 14 6	2 15 0	2 14 6	2 14 0	2 13 0½
1910	2 13 9	2 14 0	2 14 0	2 14 4	2 15 0	2 15 6	2 14 9	2 15 0	2 15 0	2 15 0	2 15 0	2 15 0	2 14 7½
1911	2 16 0	2 16 0	2 16 0	2 16 0	2 16 0	2 16 0	2 16 0	2 16 0	2 16 0	2 14 6	2 15 0	2 15 0	2 15 8½
1912	2 17 4½	2 17 6	2 17 6	3 1 1½	3 2 6	3 3 9	3 6 3	3 7 6	3 10 10½	3 12 6	3 13 3½	3 14 6	3 5 4
1913	3 15 7	3 15 0	3 11 10½	3 11 4½	3 10 2½	3 6 10½	3 4 2½	3 2 9	3 1 9	3 1 0	2 19 3	2 17 2½	3 6 5
1914	2 17 2½	2 18 0	2 18 0	2 17 0	2 17 0	2 16 7½	2 16 0	3 2 10	3 1 0	2 19 9½	2 16 11½	2 18 1½	2 18 2
1915	3 1 2½	3 3 11	3 5 9	3 18 8½	3 13 7	3 14 1	3 15 0	3 13 3	3 12 0½	3 11 1	3 14 0	4 3 3	3 12 2½
1916	4 4 6½	4 11 6	4 11 6½	4 7 6	4 7 6	4 7 6	4 10 0	4 12 10	4 12 6	4 12 6	4 12 6	4 12 6	4 8 6½
1917	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6
1918	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6
1919	4 12 6	4 12 6	4 12 6	4 12 6	7 2 6	7 5 0	8 8 5	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	7 3 10
1920	9 13 9	10 0 0	10 5 3	10 15 3	11 10 0	12 2 6	12 5 0	13 1 3	14 7 6	14 5 0	14 5 0	14 5 0	12 12 1½
1921	12 11 8	10 8 9	9 2 6	8 2 0	8 0 0	8 0 0	8 0 0	8 1 8	7 4 0	6 7 6	5 7 6	4 1(10	8 0 2
1922	5 5 0	4 17 6	4 15 0	4 15 0	4 12 6	4 12 6	4 12 6	4 12 6	4 11 3	4 10 0	4 10 0	4 10 0	4 13 7½
1923	4 12 8½	5 0 2	6 2 6	6 8 7½	6 2 5	5 11 9	5 9 1½	5 4 0	5 0 0	5 0 9	5 0 7	5 2 9	5 7 11½
1924	5 3 0	5 3 0	5 3 0	5 3 0	5 2 10	5 1 3	4 17 11	4 15 6	4 13 6	4 10 1½	4 10 0	4 10 3	4 17 9½
1925	4 10 0	4 9 0	4 6 9	4 5 2½	4 3 0	4 0 1½	4 17 1½	3 15 7½	3 14 3½	3 13 4½	3 12 4½	3 13 2½	4 1 9
1926	3 14 9	3 15 3	3 15 6	3 15 3½	3 17 6	4 5 9	4 16 9	*	*	*	*	4 12 6	4 0 1½
1927	4 13 9½	4 13 3	4 11 1½	4 9 4½	4 6 1½	3 19 1½	3 16 1½	3 15 6	3 13 4½	3 14 0	3 13 6½	4 1 6	4 1 6
1928	3 13 2½	3 12 3½	3 12 3	3 12 3	3 11 6	3 10 0	3 8 3	3 7 8½	3 7 6	3 7 9½	3 8 3	3 7 6	3 9 10½
1929	3 8 3½	3 10 4½	3 10 10½	3 11 0	3 11 2½	3 12 0	3 12 4½	3 14 6	3 15 1½	3 17 0	3 17 0	3 17 0	3 13 1½
1930	3 17 0	3 17 0	3 17 0	3 17 0	3 17 0	3 17 0	3 15 0	3 12 0	3 12 0	3 12 0	3 10 1½	3 9 6	3 14 4½
1931	3 9 6	3 9 6	3 9 6	3 9 6	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 10
1932	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0
1933	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0
1934	3 7 0	3 9 6	3 13 2½	3 14 0	3 14 0	3 14 0	3 14 0	3 14 0	3 14 0	3 14 0	3 14 0	3 14 0	3 12 11½
1935	3 14 0	3 14 0	3 14 0	3 14 0	3 14 0	3 14 0	3 14 0	3 14 0	3 14 0	3 14 0	3 18 0	3 18 0	3 14 8
1936	3 18 0	3 18 0	3 18 0	3 18 0	3 18 0	3 18 0	4 3 0	4 3 0	4 3 0	4 3 0	4 3 0	4 9 0	4 1 0
1937	4 9 0	4 9 0	4 9 0	4 9 0	4 9 0	4 9 0	5 9 0	5 9 0	5 9 0	5 9 0	5 14 0	5 14 0	4 19 10
1938	5 14 0	5 14 0	—	—	—	—	—	—	—	—	—	—	—

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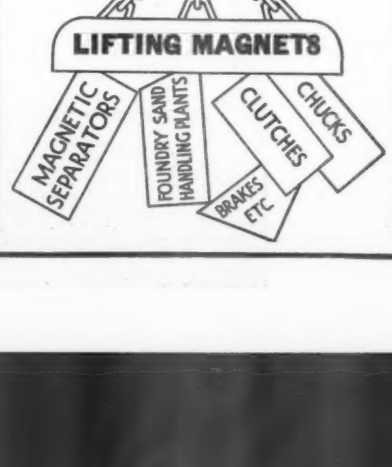
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